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An Assessment of Estuarine and Nearshore Marine Environments

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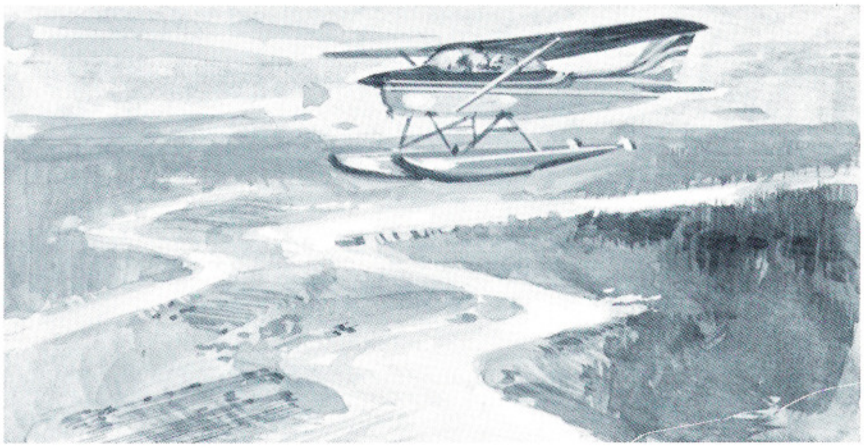
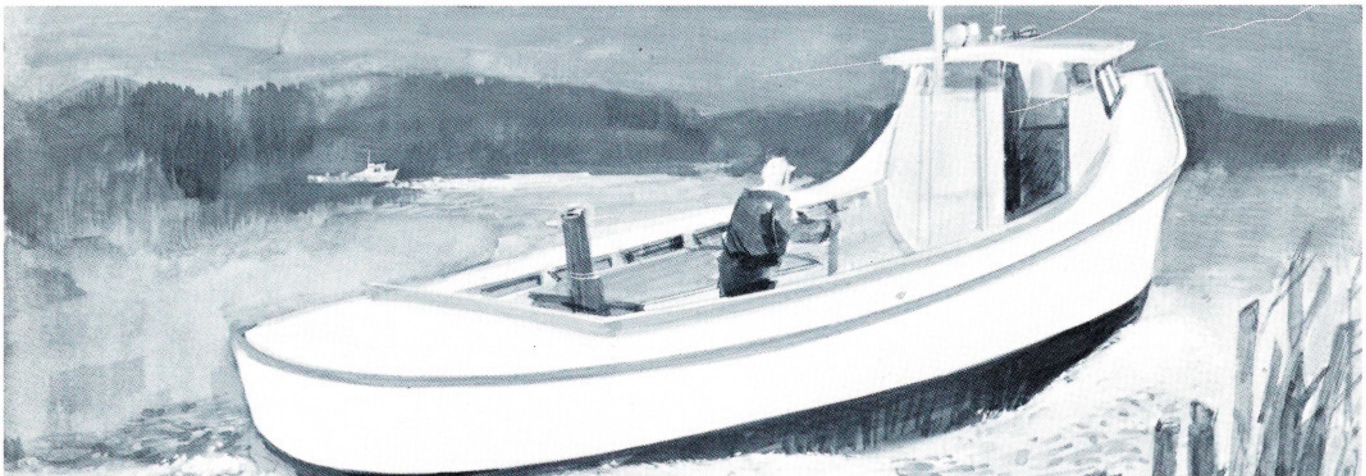
AN ASSESSMENT OF ESTUARINE AND NEARSHORE MARINE ENVIRONMENTS

PERFORMED FOR THE FISH AND WILDLIFE SERVICE,
U.S. DEPARTMENT OF THE INTERIOR,
AS PART OF THE 1975 NATIONAL WATER RESOURCES ASSESSMENT





VIRGINIA INSTITUTE OF MARINE SCIENCE
Gloucester Point, Virginia 23062

July 1975

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Fish and Wildlife Service
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1975 National Water Resources Assessment

by the

Virginia Institute of Marine Science

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FOREWORD

This report is the result of a study conducted by the Virginia Institute of Marine Science for the U. S. Fish and Wildlife Service (USF&WS), U. S. Department of Interior, to provide background information on estuarine and nearshore marine environments for the U. S. Water Resources Council for use in the 1975 National Assessment of Water and Related Lands.

The charge presented to us by USF&WS required a strong emphasis on stresses and threats to resource bases, to enable water resources planners to evaluate impacts of various water resource use projections. In some instances, adherence to the charge has resulted in a description of a region or its problems that appears more pessimistic than might actually be the case. Natural systems such as most of our nation's estuaries have a remarkably great, although unpredictable, resilience and recovery capability from one-time catastrophes (as was demonstrated during the past few years by Chesapeake Bay's recovery from Tropical Storm Agnes' impacts[1]). This resiliency, however, is strained by continuous low level, apparently innocuous stresses, particularly where many individual minor stresses combine to assault a system in a more or less unremitting manner.

State and local initiatives, spurred by Federal guidance and funding, are addressing many of the more serious problems facing the estuaries. There is promise that major programs such as clean water and clean air legislation and coastal zone and land use management are, if not always restoring our estuarine and nearshore systems to their former conditions, at least arresting the precipitous decline of many of these systems and maintaining presently ecologically viable systems.

It is hoped that this report will serve as an introduction (albeit brief) to the nation's estuarine and nearshore marine problems for those persons unfamiliar with these regions, their resources, and the problems and stresses being applied to these systems as modern civilization attempts to coerce or persuade Nature to act in accordance with the wishes of man. Hopefully, in the not too distant future, modern civilization will learn to coexist peacefully with Nature and many of the problems highlighted in this report will be relegated to the history books.

This document was not prepared for those persons knowledgeable and concerned about estuarine and nearshore marine environments who might peruse this document in the hopes of obtaining new information and insights with regard to their specific areas of concern. The information contained in this report has been obtained solely from existing sources, but has been given our interpretation and contextual arrangement. We do not accept responsibility for the accuracy of the information used, but responsibility for any inaccuracies of interpretation or presentation is wholly ours.

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[1]"Report on the Effects of Tropical Storm Agnes on the Chesapeake Bay Estuarine System," J. Davis, ed., Chesapeake Research Consortium Publication No. 34, Johns Hopkins University, Baltimore, Maryland.

As project coordinator, I wish to express my appreciation to the members of the study team who, despite heavy time constraints, managed to bring this document to its present state. Particular thanks must go to Mr. Ernie Warinner, who bore the brunt of the task of pulling the descriptive information together, Mr. Bart Theberge and Mr. Clay Jones who served the same role with regard to the institutional information, and Drs. Waldon Kerns and Ivar Strand who did the same for the resource information. Ms. Beverly Laird deserves particular mention as the individual who melded all of the disparate sections into this single report in the capacity of day-to-day compositor, editor, and general coordinator.

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Letters requesting assistance in locating publications and information for this study were addressed to many federal, interstate, and state agencies and visits and phone contacts were made with others. Particular thanks go to these agencies for providing the basic information for this report:

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- Pacific Northwest Environmental Research Laboratory, Corvallis;

National Marine Fisheries Service, Juneau;

National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, Coastal Zone Information Center;

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- Galveston District
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CHAPTER 1
COASTAL AND NEARSHORE ENVIRONMENTS

J. E. Warinner, M. Nolan,
C. Becker, R. W. Middleton, W. Rizzo

The characteristics of nearshore and coastal environments and estuaries are largely determined by such major factors as 1) geological history, 2) tidal amplitude, 3) weather, 4) currents, and 5) latitude.

Geological history determines the shape of the shore and estuaries, the shape and extent of the continental shelves, the volcanic islands of the Pacific and Caribbean, and the type of beach along the shorelines. Tidal amplitude together with the shape of the coastal indentation determines current velocities and the zonation of biological species and determines to some extent the uses to which estuaries can be put. Weather conditions determine the amount of rainfall, runoff and erosion and the severity of storm-induced damages to coastal areas as well as the shifting of dunes on sandy shores. Longshore currents determine the littoral drift which forms bars and spits and affects the distribution of nutrients and water temperature on both Atlantic and Pacific coasts. Latitude, together with climate, determines the amount and duration of sunlight available for primary production and largely determines water temperature which in turn affects speciation in specific localities.

GEOLOGICAL HISTORY

Past and present glaciation in the regions of New England north of New York City and in the states of Washington and Alaska is largely responsible for the much sculptured coast, fiord-like estuaries, rock shores and gravelly beaches of these northern regions. The broad continental shelves found along most of the east coast from Georges Bank to Fort Lauderdale and the Gulf coast from Cape Romano to Mexico, together with the relatively flat and low profile of the coastal landforms, permit the development of tremendous stretches of barrier islands which protect the mainland from the forces of the sea. In the tropical seas where the waters are clear and warm, coral reefs are prominent features which protect the shoreline from the full force of the ocean waves. On the west coast, the continental shelf is narrow and much of the coast consists of steep banks or abrupt cliffs resulting in narrow beaches and active erosion from wave action.

The Caribbean islands of Puerto Rico and the Virgin Islands and the Pacific islands of Hawaii, Samoa, and Guam are mountains that rise abruptly from the ocean floor. These lack continental shelves and, being in warm tropical seas, are characterized by coral reefs and beach and bluff configurations of the shoreline.

TIDAL AMPLITUDE

Tides are large scale rises and falls of sea level due to the gravitational attraction of the sun and moon. This rocking motion in the ocean results in nodes where there is little or no sea level change and regions of large amplitude. In regions of the coast near the nodes, there is little tidal effect while in regions of large amplitude the tidal fluctuation is greater. When the tidal wave reaches the shallow waters of the coast or estuary, it is transformed into a translational wave and the water flows in and out of the estuaries. The shape of the basin may magnify the effect of the tide such as occurs in the Bay of Fundy. The tidal ranges along the Northeast coast and the Pacific Northwest are quite large while those along the Southeast coast and in the Gulf of Mexico are srall. Tidal amplitudes are also small in the Caribbean and in the region of the Pacific islands of Hawaii. The Great Lakes, while not strictly estuarine, are of such size that atmospheric pressure changes and wind over the lakes cause intermittent and irregular seiches which have the same effect on the shoreline as tides.

WEATHER

Wind and rainfall have a dramatic effect on coastal areas and estuaries. The east coast of the United States and the Gulf coasts are subjected to tropical and subtropical storms and hurricanes with some frequency. These affect the coastlines in several ways. Wind-induced waves may cause significant damage directly to the shoreline and man-made structures, or storm surges many inundate lowlands causing much flood damage and introducing salt water into predominantly freshwater environments. The winds themselves may cause significant shifting of sand dunes and the shoaling of estuaries and channels, sometimes closing off lagoons or sounds from exchange with the sea and opening new channels by breaking barrier islands. Rainfall from tropical or subtropical storms can have a substantial effect on estuaries by wholesale erosion of inland areas with the subsequent transport of sediment loads downstream into the estuaries. Rivers draining large areas of the country transport large volumes of water. Where such rivers as the Yukon and the Mississippi drain easily erodable soil, sediment loads dumped at the mouths of these rivers cause the formation of large deltas of new land. The Southern California region is very dry with little runoff contrasted with significant runoff and erosion of the young mountains along the North Pacific coast.

CURRENTS

Large scale currents such as the Gulf Stream and Labrador Current on the east coast and the California currents on the west coast have a significant effect on water temperatures and species distribution along the coasts. The cold Labrador Current flows southward along the northeast coast of the United States and meets the warm Gulf Stream as it bends away from the southeast coast at Cape Hatteras. This not only results in rough choppy seas off of Diamond Shoals with its deserving name, the "graveyard of the Atlantic," but results in a rather distinct break in biological species north and south of Cape Hatteras.

The prevailing wind direction off Southern California during several months of the year forces the California Current offshore with a resulting upwelling of cool, nutrient-rich deep water over the narrow continental shelf.

LATITUDE

The temperature of the seas in the lower latitudes, the longer periods of daylight and clear water of the Caribbean and tropical Pacific combine to provide favorable conditions for reef formation around Puerto Rico, the Virgin Islands, Southern Florida, and Hawaii. The temperature regimes, a function of latitude, are largely responsible for the species composition and distribution along the coasts and in the estuaries of the different coastal regions. Latitudinal-related temperature is responsible for the formation of pack ice and glaciers in Alaska, which have strong erosional implications.

ESTUARINE ENVIRONMENTS

Estuaries have been defined and classified in several ways depending on the point of view of the author. Estuarine zone is defined in the 1970 National Estuarine Pollution Study (80) as:

> "the geographic zone including the coastal counties between the landward limit of tidal influence and the three-mile limit to seaward" although the "natural estuarine environment extends from the landward limit of tidal influences to the measurable seaward effect of freshwater runoff."

Odum, in Fundamentals of Ecology (22) describes an estuary as:

> "a river mouth where tidal action brings about a mixing of salt and fresh water. Shallow bays, tidal marshes and bodies of water, behind barrier beaches are included in the heading of 'estuarine waters'."

The U. S. Water Resources Framework Study (107) describes the estuary of the lower Mississippi as that area inundated by the Standard Project Hurricane with all existing and authorized hurricane protection works in place.

The Federal Water Pollution Control Act states:

> "the term 'estuarine zones' means an environmental system consisting of an estuary and those transitional areas which are consistently influenced or affected by water from an estuary

> such as, but not limited to, salt marshes, coastal and intertidal areas, bays, harbors, lagoons, inshore waters, and channels, and the term 'estuary' means all or part of the mouth of a navigable or interstate river or stream or other body of water having unimpaired natural connections with open sea and within which the sea water is measurably diluted with fresh water derived from land drainage"[1].

It is obvious that certain definitions are legalistic while others are functional. Since we are dealing in this report with the nation's water resources, the definition of estuaries and nearshore environments will be rather broadly interpreted.

While every estuary and coastal zone is unique, certain similarities exist even among widely separated estuaries that make it possible to classify the hundreds of them into a relatively few types. Table 1.1 is a classification of coastal ecological systems and subsystems according to characteristic energy sources as developed by Odum, Copeland, and McMahan (17). This classification applied to Water Resources Council Aggregated Subareas is shown in Table 1.2.

Each biophysical region has a mixture of estuarine and nearshore environments. Ecological niches will be filled by similar types of organisms on the east and west coast and the Gulf coast but not necessarily by the same species. Some examples of the niche substitutions are shown in Table 1.3.

The characteristics of estuarine circulation and water quality for different environments of the coastal biophysical regions of the United States are shown in Table 1.4.

DESCRIPTION OF ESTUARINE AND NEARSHORE ENVIRONMENTS BY REGION (Figure 1.1)

New England Region (01)

Description

The coastline in the New England Region consists of a diverse array of ecological features. The shoreline which constitutes the land-water interface is some 4,350 miles (6999km) long. In the northernmost portion of this region, the coastal zone is characterized by a rugged rocky shoreline with many deep, narrow inlets and coastal islands. There is also a large number of rivers and streams which flow into the coastal waters creating a variety of estuarine and wetlands regimes, rocky shores, and some sandy beaches.

[1]Federal Water Pollution Control Act, P.L. 92-500, 33 USC 1155.

Table 1.1. A Classification of Coastal Ecological Systems and Subsystems According to Characteristic Energy Sources.

Category	Name of Type	Characteristic energy source or stress
A. Naturally Stressed Systems of Wide Latitudinal Range		High Stress Energies
	A-1. Rocky sea fronts and intertidal rocks	--breaking waves
	A-2. High energy beaches	--breaking waves
	A-3. High velocity surfaces	--strong tidal currents
	A-4. Oscillating temperature channels	--shocks of extreme temperature range
	A-5. Sedimentary delta	--high rate of sedimentation
	A-6. Hypersaline lagoons	--briny salinities
	A-7. Blue-green algal mats	--temperature variation and low nighttime oxygen
B. Natural Tropical Ecosystems of High Diversity		Light and Little Stress
	B-1. Mangroves	--light and tide
	B-2. Coral Reefs	--light and current
	B-3. Tropical meadows	--light and current
	B-4. Tropical inshore plankton	--organic supplements
	B-5. Blue water coasts	--light and low nutrient
C. Natural Temperature Ecosystems with Seasonal Programming		Sharp Seasonal Programming and Migrant Stocks
	C-1. Tidepools	--spray in rocks, winter cold
	C-2. Bird and mammal islands	--bird and mammal colonies
	C-3. Landlocked sea waters	--little tide, migrations
	C-4. Marshes	--lightly tidal regimes and winter cold
	C-5. Oyster reefs	--current and tide
	C-6. Worm and clam flats	--waves and current, intermittent flow
	C-7A. Temperate grass flats	--light and current
	C-7B. Shallow salt ponds	--small waves; light energy concentrated in shallow zone
	C-8. Oligohaline systems	--saltwater shock zone, winter cold
	C-9. Medium salinity plankton	--mixing intermediate salinities with some stratification
	C-10. Sheltered and stratified estuary	--geomorphological isolation by sill
	C-11. Kelp beds	--swells, light and high salinity
	C-12A. Neutral embayments	--shelfwaters at the shore
	C-12B. Coastal plankton	--eddies of larger oceanic systems
D. Natural Arctic Ecosystems with Ice Stress		Winter Ice, Sharp Migrations and Seasonal Programming
	D-1. Glacial fiords	--icebergs
	D-2. Turbid outwash fiords	--outflow of turbid icewater lens
	D-3A. Ice stressed coasts	--winter exposure to freezing
	D-3B. Inshore Arctic ecosystems with ice stress	--ice, low light
	D-4. Sea ice and under-ice plankton	--low light
E. Emerging New Systems Associated with Man		New but Characteristic Man-Made Energy Sources and/or Stresses
	E-1. Sewage waste	--organic and inorganic enrichment
	E-2. Seafood wastes	--organic and inorganic enrichment
	E-3. Pesticides	--an organic poison
	E-4. Dredging spoil	--heavy sedimentation by man
	E-5. Impoundment	--blocking of current
	E-6. Thermal pollution	--high and variable temperature discharges
	E-7. Pulp mill waste	--wastes of wood processing
	E-8. Sugar cane waste	--organics, fibers, spoils of sugar industry wastes
	E-9. Phosphate wastes	--wastes of phosphate mining
	E-10. Acid waters	--release or generation of low pH
	E-11. Oil shores	--petroleum spills
	E-12. Piling	--treated wood substrates
	E-13. Salina	--brine complex of salt manufacture
	E-14. Brine pollution	--stress of high salt wastes and odd element ratios
	E-15. Petrochemicals	--refinery and petrochemical manufacturing wastes
	E-16. Radioactive stress	--radioactivity
	E-17. Multiple stress	--alternating stress of many kinds of wastes in drifting patches
	E-18. Artificial reef	--strong currents
F. Migrating Subsystems that Organize Areas		Some Energies Taxed from Each System

Source: Coastal Ecological Systems of the United States, by H. T. Odum, B. J. Copeland, and E. A. McMahan (1974). The Conservation Foundation, in cooperation with National Oceanic and Atmospheric Administration, Office of Coastal Environment, Vol. I, pp. 25-28.

Table 1.2. Classification of Coastal Ecological Systems and Subsystems (Odum, Copeland, McMahan) by Water Resources Council Regions.

	New England	Middle Atlantic	South Atlantic-Gulf	Lower Mississippi	Texas-Gulf	California-South Pacific	Columbia-North Pacific	Alaska	Great Lakes	Hawaii	Caribbean
Region Code	01	02	03	08	12	18	17	19	04	20	21
Naturally Stressed Systems of Wide Latitudinal Range											
Rocky sea front and intertidal rocks	x					x	x	x		x	x
High energy beaches	x	x	x	x	x	x	x	x	x	x	x
High velocity surfaces	x		x		x		x	x		x	x
Oscillating temperature channels	x										
Sedimentary delta			x	x	x		x	x			x
Hypersaline lagoons			x		x	x				x	x
Blue-green algal mats					x	x				x	x
Natural Tropical Ecosystems of High Diversity											
Mangroves			x							x	x
Coral Reefs			x							x	x
Tropical meadows			x		x					x	x
Tropical inshore plankton			x							x	x
Blue water coast			x							x	x
Natural Temperature Ecosystems with Seasonal Programming											
Tidepools	x	x	x			x	x	x		x	
Bird and mammal islands	x			x		x	x	x			
Landlocked sea waters	x						x				
Marshes	x	x	x	x	x	x	x	x	x		x
Oyster reefs	x	x	x	x	x		x			x	x
Worm and clam flats	x	x	x	x	x	x	x	x		x.	
Temperate grass flats / Shallow salt ponds	x	x	x	x	x	x	x	x		x	
Oligohaline systems	x	x	x	x	x	x	x	x			
Medium salinity plankton	x	x	x	x	x	x	x	x			
Sheltered and stratified estuary	x				x		x				
Kelp beds	x					x	x	x			
Natural embayments	x	x	x	x		x	x	x			
Coastal plankton	x	x	x			x					
Natural Arctic Ecosystems with Ice Stress											
Glacial fiords								x			
Turbid outwash fiords								x			
Ice stressed coasts								x			
Inshore Arctic ecosystems with ice stress								x			
Sea ice and under-ice plankton								x			
Emerging New Systems Associated with Man											
Sewage waste	x	x	x	x	x	x	x	x	x	x	x
Seafood wastes			x	x	x		x	x	x		x
Pesticides	x	x	x	x	x	x			x		x
Dredging spoil	x	x	x	x	x	x			x	x	x
Impoundment	x	x	x	x	x	x					
Thermal pollution	x	x	x			x			x	x	x
Pulp mill waste	x	x	x	x	x	x	x	x	x	x	
Sugar cane waste				x						x	x
Phosphate waste	x		x		x				x		
Acid waters		x							x		
Oil shores	x	x	x	x	x	x	x	x		x	x
Piling	x		x	x	x		x		x		
Salina						x				x	
Brine pollution			x		x						
Petrochemicals	x	x	x	x	x	x			x	x	
Radioactive stress							x				
Multiple stress	x	x	x	x	x	x	x			x	x
Artificial reef											
Migrating Subsystems that Organize Areas	x	x			x		x				x

Table 1.3. Examples of West and East Coast Niche Substitutions, Gulf Coast Equivalents and Tropical Types when Stressed.

System Type	Description of Role	Tropical Stressed	Upper West Coast	Gulf Coast	Upper East Coast
Oligohaline river mouth	Clam with great capacity to burrow from cold and adapt to salinity variation		Soft-shell clam *Mya arenaria*	*Rangia*	Soft clam *Mya arenaria*
	Oyster reef niche	American oyster *Crassostrea virginica*	Pacific oyster *Ostrea gigas*	American oyster *Crassostrea virginica*	American oyster *Crassostrea virginica*
Middle salinity estuary	General crab carnivore, moving in and out of varying salinity	Blue crab *Callinectes*	Dungeness crab *Cancer*	Blue crab *Callinectes*	Green crab *Cancer*
High salinity estuary	Top carnivore in bottom irregularities	Spiny lobster *Panulirus*	King crab *Paralithodes*	Stone crab *Menippe*	American lobster *Homarus*
Kelp system	Algal forests, bottom attached seaward of surf		*Macrocystis*		*Laminaria*
Beach and surf zone	Deep digging clam adapted to heavy energies just seaward of breakers	Surf clam *Spisula*	Razor clam *Siliqua*	Surf clam *Spisula*	Surf clam *Spisula*
	Surf zone sand dollar	*Mellita*	*Denraster*	*Mellita*	*Echinarachnius*
Intertidal rocks	Grazers of intertidal rocks, periwinkles	*Littorina ziczac*	*Littorina planaxis* *Littorina scutellata*	*Littorina irrorata*	*Littorina litorea*
	Intertidally protected filter feeders, barnacles, sea lettuce	*Balanus amphitrite* *Ulva*	Gooseneck barnacle *Lepas* *Ulva*	*Balanus eburneus* *Ulva*	*Balanus balanoides* *Ulva*
Coastal plankton	Zooplankton eater	Anchovy	Pacific herring, Sardines	Menhaden, Threadfin	Atlantic herring Alewives

Source: Adapted from Coastal Ecological Systems of the United States, by H. T. Odum, B. J. Copeland and E. A. McMahan (1974), Volume I, p. 46 The Conservation Foundation in cooperation with National Oceanic and Atmospheric Administration, Office of Coastal Environment.

Table 1.4. Characteristic Natural Estuarine Zone Circulation and Water Quality Conditions.

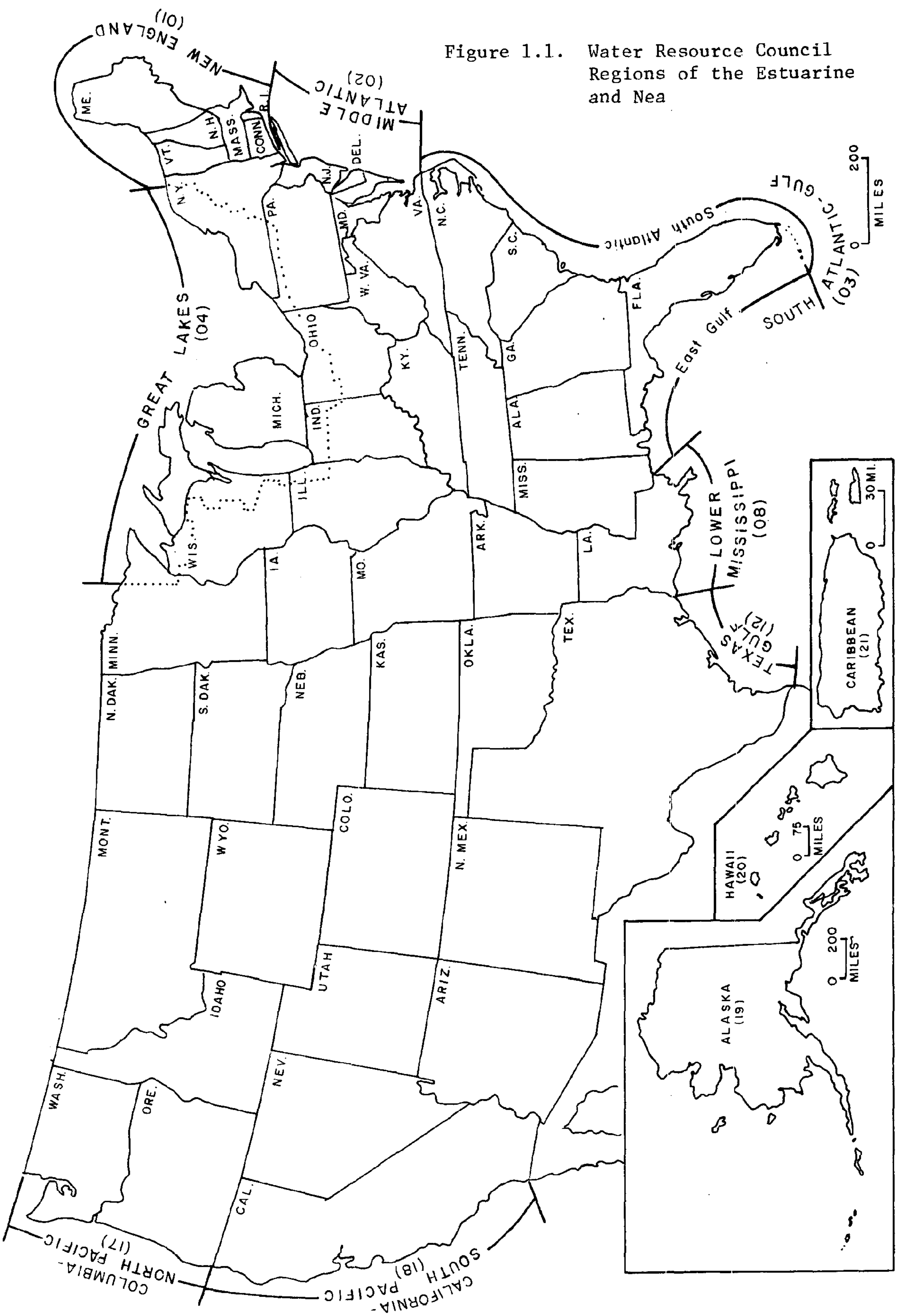
Bio-physical Region	(1) Smooth Shoreline	(2) Indented Shoreline	(3) Marshy Shoreline
North Atlantic	Deep near shore, oceanic water, longshore currents some suspended sand and clay	Deep near shore, oceanic water, erratic tidal currents; eddies and tidal pools	Strong currents in many small channels through marsh, some turbidity, high oxygen
Middle Atlantic	Ocean water, longshore currents; suspended mud, clay silt	Generally shallow, suspended mud and sand, oceanic water	Moderate currents in well-defined channels, high dissolved organic material, little turbidity, high oxygen
Chesapeake	Longshore tidal currents highly variable salinities, small amounts of organic material	Moderate tidal currents, highly variable salinities, some turbidity	Poorly defined channels, small currents, dissolved organic material, moderate fluctuation of oxygen
South Atlantic	Primarily tidal and wave induced currents, oceanic water with mud, clay and silt	Moderate tidal currents, highly variable salinities some turbidity	Small currents, high color, high dissolved organics, highly variable oxygen, high temperatures
Caribbean	Clear ocean water, gentle currents, warm temperatures throughout the year	Clear ocean water, gentle currents, eddies, warmer than ocean	High dissolved organics, high color, suspended mud, very small currents, hot
Gulf of Mexico	Clear, generally warm ocean water, longshore currents	Very small currents, ocean water with slight turbidity warmer than ocean	High dissolved organics, high color, very small currents, slightly to moderately turbid, high temperature
Southwest Pacific	Strong wave action cool oceanic water, some silt and clay turbidity	Moderate suspended solids, erratic currents, high oxygen, cool	High suspended soilds erratic tidal currents, warmer than ocean and rivers
Northwest Pacific	Strong wave action cold ocean water, some silt and clay turbidity	Moderate suspended solids, erratic currents, high oxygen, cold	High suspended solids, erratic tidal currents, warmer than ocean and rivers
Alaska	Very cold oceanic water, usually ice, salinities slightly depressed	Very cold oceanic water, overlain by some fresh water, high oxygen	Very cold water, variable salinity, much fine silt, debris from freezing
Pacific Islands	Clear, warm ocean water, strong wave action	Clear ocean water, gentle currents, eddies, warmer than ocean	High dissolved organics, color, high suspended mud, very small currents, hot

Source: The National Estuarine Pollution Study, 1969. Federal Water Pollution Control Administration, U. S. Department of Interior, Vol. IV, pp. 74-75.

Table 1.4. Characteristic Natural Estuarine Zone Circulation and Water Quality Conditions (continued)

(4) Unrestricted River Entrance	(5) Embayment, Coastal Drainage Only	(6) Embayment, Continuous Upland River Flow	(7) Fiord
Highly stratified, some turbidity, high oxygen, temperatures warmer in summer, colder in winter than ocean	Little turbidity, water of oceanic character; strong tidal currents through inlets	Little turbidity, high oxygen may be stratified, upper layer fresh, with temperatures warmer in summer, colder in winter than the ocean	
Moderate stratification, suspended mud and silt, high oxygen, strong currents	Generally shallow, small tides, clear water with lowered salinity, high oxygen	Variable stratification, suspended mud and silt, high oxygen, small amounts of organic material	
Moderate stratification suspended mud and silt, high oxygen, strong currents	Generally shallow, small tides, clear water with lowered salinity, high oxygen	Variable stratification suspended mud and silt, high oxygen, small amounts of organic material	
Strong stratification, high suspended mud and clay, strong currents, dissolved organics, moderate oxygen	Some color, small currents, generally shallow, high dissolved organics, highly fluctuating oxygen	Slight and variable stratification, river water cooler than ocean, slight color, some oxygen fluctuation, moderate to high suspended sediment	
Slightly turbid, strong currents, river cooler than ocean water	Very small currents, generally shallow, quite warm, clear ocean water	Slightly turbid, eddying currents, slight stratification, high oxygen	
Slightly turbid, strong currents, river cooler than ocean water	Very small currents except in inlet, shallow, warm, slight turbidity from sand and silt, highly fluctuating oxygen	Slight and variable stratification, river water cooler than ocean some oxygen fluctuation	
Strong stratification offshore bar formation cool, high oxygen	Some suspended silt, erratic currents, cool, high oxygen	Moderate to strong stratification, high suspended silt, strong currents, high oxygen cool	
Strong stratification, offshore bar formation, cold, high oxygen	Some suspended silt, erratic currents, cold, high oxygen	Moderate to strong stratification, high suspended silt, strong currents, high oxygen, cold	
Strong currents, high suspended solids frequently glacial in origin, very cold	Very cold organic water, much ice, surface layer of fresh water, high oxygen	High turbidity with glacial debris, seasonal freeze-ups, strong currents during runoffs	Stagnant below sill depth, very little oxygen, high salinity hydrogen sulfide
Slightly turbid, strong currents, river cooler than ocean water	Very small currents, generally shallow, quite warm, clear ocean water	Slightly turbid, eddying currents, slight stratification, high oxygen	

Figure 1.1. Water Resource Council Regions of the Estuarine and Nea



The different estuarine basins in this region consist mainly of submerged river valleys with unmodified mouths or a few coastal fiords (54) with a surface area of 385,100 acres (155,815 km^2).

The major embayments which may be found in the New England Region include:

St. Croix River Estuary and Cobscook Bay
Penobscot River Estuary
Saco River Estuary
Great Bay-Piscataqua River Estuary Embayment
Merrimack River Estuary
Boston Harbor
Cape Cod Bay
Buzzards Bay
Vineyard Sound
Narragansett Bay
Long Island Sound (also covered in New York) (54).

According to the classification system of Odum, Copeland and McMahan (Table 1.1), a large portion of the much dissected coast of Maine with its high tidal range represents a naturally stressed system of wide latitudinal range consisting of rocky sea fronts and intertidal rocks, and high velocity channels (Classification A-1 and A-3 and C-1).

Rock ledges with pocket beaches are found in the northern section of New Hampshire while the southern portion possesses extensive barrier beaches in front of tidal marshes.

The coastline of Massachusetts is extremely diverse. The area excluding Cape Cod has a very irregular coastline with many indentations. Cliffs and bluffs become apparent with intermingling sections of dunes. The shoreline of the Cape Cod peninsula consists almost entirely of sandy beach varying from relatively narrow barrier beaches along the southern portion to extensive dune formation along the outer sections of the lower Cape. From Buzzards Bay to the Rhode Island border, the coast is a mixture of barrier beaches, deep indentations, low rocky headlands, marshes and ponds. Martha's Vineyard, Nantucket and the Elizabeth Islands are located off the southern coast (55,106).

The Rhode Island coastline is dominated by Narragansett Bay, a drowned river embayment covering some 170 square miles. The entire coastal area contains many freshwater ponds and lakes as well as saltwater ponds behind barrier beaches along the southern coastal area (106).

The Connecticut coastline is very irregular with many bays, coves, and offshore islands. Many of the beaches are narrow with the normal tides approaching the backshore. West of the Norwalk Harbor, the coastline becomes rockier (106).

Problems

Major Concerns:
water pollution
wetlands conservation
recreation
marine transportation (pollution)

Significant Concerns:
living resources
coastal erosion
tidal flooding

Lesser Concerns:
thermal dissipation
solid waste disposal
extraction of non-living resources (106)

Major water quality problems occur over the entire area. Raw and inadequately treated non-industrial and industrial waste loads are the major cause, but sedimentation problems occur as a result of the pulp and paper, textile and food processing operations. To a large extent, the pollution is related to upstream usage (106).

Boston Harbor, Massachusetts is the receptacle for the drainage and waste of four major streams. The major problems are with municipal waste, oil, debris, and refuse pollution. Narragansett Bay, Rhode Island, suffers not only from municipal and industrial pollution, but has a severe problem with oil pollution. Thermal pollution from New England Power's Brayton Point power plant is also a problem (54).

Boston, Massachusetts is a major contributor in the problem of ocean disposal and dumping (54).

In the region below Maine, shore erosion is a pertinent problem especially in areas of high development. Massachusetts, especially in the Cape Cod area, has a problem with summer home development and the problems presented by the vast numbers of tourists in the summer.

In the southern portion of the region, especially Connecticut and Rhode Island, major areas of wetlands have been permanently lost primarily due to filling and development.

Major navigation projects are proposed for the Providence River and Harbor in Rhode Island (106).

At this time, New England is a net importer of electrical energy and petroleum products. There are strong pressures to build atomic energy plants and petroleum refineries.

Middle Atlantic Region (02)

Description

The Middle Atlantic coastline is dominated by large estuaries, barrier islands and coastal marshes which form in the quiet estuarine and barrier island lagoon environments (55).

The most prominent embayments which may be found in this region include:

Raritan Bay-Hudson River (New York Harbor)
Long Island Sound
Delaware Bay
Chesapeake Bay

In New York, the western section of Long Island has a very irregular coastline, with numerous deep bays and promontories. The eastern portion becomes regular with very few indentations. The North Shore possesses narrow, rock or pebbly beaches with high bluffs and small marshes. This contrasts with the South Shore's barrier beaches and quiet back bays. The Hudson Estuary above New York City is known for its aesthetic appeal. Scenic overlooks, large estates, and historic and cultural landmarks abound. Regrettably, sections also show the effects of the concentration of people and development. Below this area extensive tidal marshes predominate, with the cliffs of Palisades a striking exception. The Raritan Bay region is characterized by high bluffs and marshlands fronted by narrow beaches intersected by numerous tidal creeks. The region to the south of Raritan Bay consists of long sandy barrier islands with back bays, salt marshes, and meadows that in some areas extend several miles inland. In Delaware and Maryland there are long, low, narrow barrier beaches fronting a series of embayments with infrequent narrow inlets connecting them to the ocean. Virginia has more variation north to south going from barrier island, mainland small buffer islands, mainland and barrier beach (106). The barrier islands in Maryland such as at Ocean City have undergone extensive development as compared to Virginia's barrier islands which are principally privately or federally owned conservation areas.

Pennsylvania's entire estuarine environment consists of a 45 mile reach of the Delaware River within the tidal influence.

Situated in the densely populated megalopolis between Washington and New York City, the Delaware River and estuary is the second largest seaport in the United States, serving nearly one-tenth of the population, and is the site of the largest concentration of oil refineries on the east coast. Despite this, the estuary contains extensive tidal and freshwater marshes on the upper east coast and is a very productive coastal region (46).

The Chesapeake Bay is one of the largest estuaries in the world, with a surface area of approximately 4,400 square miles and a length of almost 200 miles. It is a typical coastal plain estuary with a broad, shallow expanse of water having an average depth of less than 28 feet. Because of the variations in salinities, the Bay supports a wide variety of fish life, is the spawning area and nursery for many ocean fishes and is a favored habitat for the blue crab (Callinectes sapidus).

If considered as a whole, this region falls into the Virginian classification and acts as a transition zone between Arcadian and Carolinian regions (111). Oyster grounds, reefs, or "rocks" occur in abundance in the shallow bays of the coast of this region especially from New Jersey southward. One organism which may be found for the first time on the barrier beaches within this region is the ghost crab (Ocypode quadrata).

The salt marshes of this region are similar in many ways to those found in New England. In New Jersey and Delaware, there is a subtle shift from the New England type to that more characteristic of the South Atlantic and Gulf Coastal Plain. Here, there are limited areas of smooth cordgrass (Spartina alterniflora) with saltmeadow grass (Spartina patens) occupying the largest area. There is a similar zonation pattern found on the eastern shore of Maryland. The western shore of the Chesapeake Bay with its stronger freshwater influence has Spartina alterniflora in areas covered by tides, but giant cordgrass (Spartina cynosuroides) often borders tidal streams. In areas of very low salinity, freshwater species such as Olney three-square (Scirpus olneyi) may be found (17).

Problems

Major Concerns:
water pollution
wetlands conservation
recreation
marine transportation (pollution)

Significant Concerns:
living resources
coastal erosion
tidal flooding

Lesser Concerns:
thermal dissipation
solid waste disposal
extraction of non-living resources (106)

Major water quality problems occur over the entire area. Raw and inadequately treated non-industrial and industrial waste loads are the major cause.

Long Island Sound suffers not only from municipal sewage pollution, but also from pollution due to the practice of dumping duck wastes into waters adjacent to the duck farm operations (45). Second home development is putting increasing pressure to develop the coastal land. Nassau and Suffolk counties are also suffering from the effects of large scale dredging and erosion. The barrier beaches on the South Shore are eroding to a vast extent (48). In general, erosion is a consistent problem along the entire length of the Middle Atlantic Region.

New Jersey suffers from urban runoff and seepage and salt intrusion into freshwater supplies and is also confronted with the possibility of an offshore nuclear power plant (50).

Two U. S. Army Corps of Engineers projects with possible environmental effects are the inland waterway from the Delaware River to the Chesapeake Bay (Chesapeake and Delaware Canal) in Delaware and Maryland and the Delaware Bay-Chesapeake Waterway in Delaware, Maryland and Virginia (62). The major problems are associated with the widening and deepening of the Chesapeake and Delaware Canal (37).

Oil pollution poses a possibility of threat in the Delaware Bay which has the largest concentration of refineries on the east coast. Delaware Bay is unique on the Atlantic coast because it possesses the only naturally sheltered deep harbor in close proximity to refineries and industrial markets. A deepwater port, if constructed, might have major environmental impact on the area (46).

Baltimore Harbor is polluted from direct industrial discharges, sewage overflows, urban runoff, and municipal sewage. There is also the spoils disposal problem from the maintenance dredging of the harbor. As with the Delaware Bay, a possible environmental impact is conceivable if the plans for a deep-draft channel are carried out (84).

The greatest pollution problems in the Chesapeake Bay occur in its constricted sub-estuaries downstream from urban and industrial concentrations. Sewage represents the biggest input especially in the Potomac and James estuaries. The Susquehanna River suffers from municipal, industrial, and acid mine wastes. There is also a serious problem with erosion along the shores of the Bay. The proposals to divert water from the Susquehanna River and enlarge the Chesapeake and Delaware Canal could have major effects upon the water quality, salinity patterns, and circulation patterns of the upper Chesapeake Bay (63).

South Atlantic-Gulf Region (03)
(North Carolina-Georgia)

Description

In the South Atlantic Region, the coastline is a vast expanse of barrier islands, marshes, and estuaries. Along most of the North Carolina coast extends a series of barrier islands known as the Outer Banks. Behind the islands lie large estuaries containing small islands, and the mainland shore. The primary difference between these barrier islands as compared to those further north is the distance between the islands and the mainland. The Outer Banks lie 20-30 miles off the mainland while further north about 10 miles is the greatest distance between barrier islands and mainland.

There are two types of islands: the natural and the stabilized. The natural island has a wide beach and a zone of low, irregular dunes which are broken periodically by overwash beaches. The stabilized island possesses a narrow beach zone, with high artificial foredunes maintained by transplanted and fertilized growths of American beachgrass, Ammophila breviligulata (55).

Major estuaries of the South Atlantic Region are:

Pamlico River	Alligator River
Pamlico Sound	Croatan Sound
Cape Fear	Bogue Sound
Georgia Salt Marshes	New River
Albemarle Sound	Topsail Sound
Currituck Sound	

North Carolina possesses more acres of oyster beds than all the other states in this region combined. This reflects the extensive shallow water areas behind the barrier islands and the waters are less turbid than those in Georgia (112).

The Pamlico River is one of the major rivers in this region. This estuary is wide and shallow with wide sandy areas along the shore.

The marshes behind the Outer Banks of North Carolina consist of either vast, pure stands of black needlerush, primarily Juncus roemerianus, or stands of Spartina patens that resemble the salt meadows of New England. The area south of Cape Lookout, North Carolina is the region for optimum development of salt marshes in the United States. These low marshes characterized by vast expanses of smooth cordgrass, Spartina alterniflora, form behind narrow barrier islands in areas influenced by heavy silt deposition from large rivers. There is only a small amount of open water behind the barrier islands. This region includes the famous Sea Islands of South Carolina and Georgia. The broad, level expanses of grass and soft sediment develop dendritic creeks and deep tidal channels in vast number that are characteristic when viewed from the air (17).

Problems

Major Concerns:
- water pollution
- wetlands conservation
- coastal erosion
- tidal flooding
- phosphate mining

Significant Concerns:
- thermal dissipation
- living resources
- recreation
- conservation of barrier islands

Lesser Concerns:
- solid waste disposal
- extraction of non-living resources

The type of problem confronting this region is closely correlated with the type of shoreline normally found--barrier islands and marshes. The conservation of the marshes and the effects of water pollution upon this type of habitat are two of the primary problems concerning this region. Pulp mills present a problem in North Carolina and also in Georgia, particularly around Brunswick. Brunswick is also the area that is suffering from chemical processing pollution.

The barrier islands on the east coast in conjunction with the rise in sea level are moving toward the mainland. This is a natural process that maintains the integrity of the islands. The problem arises when man attempts to build on these islands to stabilize this environment. Erosion is a real problem on the barrier islands of North Carolina and South Carolina.

North Carolina is confronted with the problems of second home development and possible reservoirs along the coast. The Cape Fear River is scheduled for four nuclear power plants. Potential environmental impact may be mitigated by use of closed cycle cooling for these plants.

Other problems of the area include nuclear power plants and nuclear processing plants in the Savannah River of Georgia and possible rediversion of the Cooper River to the Santee River in South Carolina (64). This rediversion is planned to reduce shoaling in the Cooper River system, but may adversely impact some features of the Santee system. The present flow of the Cooper River results from a diversion of Santee River water in 1942.

South Atlantic-Gulf Region (03)
(Florida East Coast)

Description

The South Atlantic Region of East Florida consists of the shoreline extending from the Florida-Georgia border to the Florida Keys. This coastline consists of barrier islands occasionally broken by inlets. These barrier islands typically consist of high energy sand beaches with productive marshes or estuaries on the landward side. The shoreline is closely connected to the barrier islands by inlets and contains large amounts of marshland and riverine swamp estuary (61f).

The area is highly productive of a number of estuarine-dependent fish and shellfish, including bluefish, menhaden, American shad, porgy, croaker, mullet, spotted seatrout, pompano, spot, flounder, striped bass, anchovies, sea catfish, shrimp, crabs, oysters, clams, and scallops, and wading birds (84).

The area has been extensively developed, subjecting these ecosystems to various stresses.

Major estuaries of the area include the following:

St. Mary's River
St. Johns River
Mosquito Lagoon
Banana River
Biscayne Bay

Problems

Major Concerns:
domestic wastes
beach erosion

Significant Concerns:
thermal additions
industrial discharges
  heavy metals
  pesticides
  petrochemicals

Lesser Concerns:
dredging

The extensive residential development of this coast has caused severe pollution problems from untreated or inadequately treated sewage. This lack of treatment causes elevated levels of bacteria and increased BOD (40). This results in elimination of organisms from the estuary and renders others unsafe for human consumption. Effluent discharges, thought to be carried out to sea by the Gulf Stream, have been found to be carried back into estuaries by countercurrents and tides (41). Eutrophication from increased nutrient levels has resulted in increased turbidity, nuisance algae blooms, and fish kills.

Heavy sewage pollution has already impaired water quality in the St. Johns River, the coast between St. Johns River and Turkey Creek, Turkey Creek itself, St. Lucie River, West Palm Beach, and most of Dade County (110). The consequently high bacterial levels have caused curtailment of the shellfish industry and accelerated the eutrophication of many estuaries. Such development is expected to be heavy in the near future, compounding an already serious problem (61f).

Thermal additions from industry or power generation alter habitat, kill organisms, increase levels of toxic heavy metals, and alter the regular behavior of fish (31,57). Thermal loading problems have been evident in Biscayne Bay, necessitating a change to closed cycle cooling.

The coast between St. Mary's River and St. Johns River, the St. Johns River itself, the Oklawaha River, and the Miami area are experiencing problems with industrial pollution. Industrial growth is expanding in the region and continued growth is likely for some time (107,109).

Heavy point discharges of heavy metals, pesticides, and petrochemical and other wastes are also widespread, but less of a problem than the domestic pollution problems. Toxic levels of such wastes reduce the density and diversity of organism and pose public health problems (107,109).

Residential and industrial development results in loss of habitat from filling or draining of marshland and from construction (16).

Dredging, channelization and spoil disposal cause loss of habitat, altered estuarine circulation, increased turbidity and siltation, and altered salinity, which result in impairment of biological productivity (16).

Maintenance of the Intracoastal Waterway and artificial passes will necessitate continued dredging with its related problems. The Corps of Engineers is also involved with many beach erosion control projects in East Florida involving construction of jetties, groins, bulkheads, seawalls, and revetments, with corresponding problems of habitat loss, increased turbidity and siltation (61f).

South Atlantic-Gulf Region (03)
(East Gulf)

Description

The East Gulf area consists of the Gulf coast from Key West north to the Louisiana - Mississippi border and includes a large variety of estuarine habitats.

Major estuaries found in this region include:

- Florida Bay
- Charlotte Harbor
- Tampa Bay
- Apalachee Bay
- St. Georges Sound
- Apalachicola Bay
- Choctawatchee Bay
- Mobile Bay system
- Pascagoula and Pearl Rivers

Almost the entire Florida Gulf coast from Key West to Apalachee Bay is characterized by productive mangrove swamps or salt marshes, with only intermittent high energy sand beaches. Offshore barrier islands are present from Key West to Anclote Key. In the Ten Thousands Islands area the shoreline is a complex system of tidal creeks and mangrove swamps with islands separated by shallow tidal lagoons and natural passes. Sand beaches are infrequent in this area. The shoreline from Anclote Key to Apalachee Bay has almost no barrier islands but consists of salt marsh and intermittent sand beaches. Apalachee Bay to the Alabama border has a shoreline almost completely dominated by high-energy, wide sand beaches with large dune formations with many estuaries behind them (61f,84).

The south Florida area of the Everglades and the Ten Thousand Islands is the nursery ground of the pink shrimp which support a large fishery at the Dry Tortugas. It is also an important nursery of tarpon, snook, spotted sea trout, pompano, blue crabs and spiny lobster. Oysters grow on the roots of the mangroves. The area is the northern limit of many tropical species and is the home of many endangered species including the Everglades Kite, Florida Great White Heron, Southern Bald Eagle, Cape Sable Sparrow, Brown Pelican, Florida Mangrove Cuckoo, American alligator, American crocodile, Key deer, manatees, and Caribbean monk seals, and the endangered tropical species such as the Wood Ibis, Roseate Spoonbill, eastern Reddish Egret, and the Osprey (61f,84).

The Alabama coast is characterized by high energy sand beaches up to Mobile Bay. At the west end of Mobile Bay, barrier islands again occur offshore, and the mainland shoreline is split between high energy sand beach and tidal marsh to the Mississippi border (61f,84).

The short Mississippi Gulf coastline is in actuality formed entirely of offshore barrier islands, which are characteristically composed of high energy sand beaches grading to salt marsh in the center. The mainland shoreline has salt marshes with occasional narrow beaches from the Alabama - Mississippi border to Biloxi Bay (61f). From Biloxi Bay westward across Harrison County and the eastern half of Hancock County, the entire shoreline has been altered by seawall and artificial beach, unbroken by industrial developments. The remaining half of Hancock County to the Louisiana border consists of brackish and freshwater marsh (Pearl River Delta).

The entire east Gulf area provides habitat and important nursery grounds for estuarine dependent fish and shellfish such as menhaden, penaeid shrimp, blue crabs, oysters, spotted sea trout, croakers, mullet, snappers, red drum, pompano, flounders, and catfishes. In addition, the region is vitally important to migratory waterfowl and wading birds, as well as endangered species such as the American alligator and Brown Pelican (61f,84).

Problems

Major Concerns:
domestic and industrial pollution
dredging
diversion of freshwater flows

Significant Concerns:
pesticides
electric power
pulp and textile mill wastes
filling of marshes

Lesser Concerns:
ditching and draining

Residential development characteristically causes habitat degradation by fill and increased siltation, increased levels of pesticides from mosquito and beachfly control programs, and increased bacterial loading from inadequately treated sewage and septic tanks (16,100).

Pollution from domestic and industrial sources has caused accumulation of pesticides, heavy metals, and bacteria in such items as oysters and fish and have also endangered such species as the Osprey, Brown Pelican and Bald Eagle (100).

The Gulf coasts of Florida, Mississippi, and Alabama are subject to similar stresses.

Industrial development has effects which vary with the industry, but heavy development characteristically increases levels of heavy metals, turbidity, and petrochemical waste, causing reduction in biological productivity and/or production of fish and shellfish which are unsafe for human consumption (16,100,107).

Power demand will increase in the future. The manner of meeting this demand is uncertain on the whole, but is likely to be met with a combination of nuclear and fossil fuel power plants. A power generating complex consisting of two fossil fuel and one nuclear plant is in operation on the Crystal River in Florida, and has been demonstrated to affect the natural densities of fish in winter and summer, to have deleterious effects on all flora and fauna near the effluent canal, and to increase the concentrations of heavy metals in oysters growing near the effluent canal (19,20). Excess heat has altered the behavior of the fish communities, causing unusually high concentrations of fish around effluent canals during the winter and low concentrations during the summer.

Offshore development of the petroleum resources of the Gulf is proceeding, producing the possibilities of chronic and acute oil spills. The installation of buried pipelines and access to shore facilities requires the dredging of canals, resulting in perturbations in circulation and sedimentation patterns as well as providing another source of oil spillage (11,16,57).

The development of pulp and textile mills and other industries has added to the number of point sources of pollution in Florida especially around Pensacola and Apalachicola bays (84,100).

Dredging and channelization projects are widespread. In Florida the largest such project is the proposed cross-Florida barge canal which would involve extensive dredging and channelization, resulting in large scale spoil disposal problems, habitat loss, reduction of freshwater flow to the Everglades, altered circulation patterns, and increased sedimentation and turbidity (2,3,16).

Other projects in Florida involving dredging and channelization are presently underway and will continue in the future. These include construction and maintenance of the Intracoastal Waterway, maintenance of a channel in several harbors, and construction and maintenance of artificial passes (61f,84).

Maintenance of a 40-foot ship channel in Mobile Bay contributes to altered circulation patterns, and increased salinity intrusion, local turbidity and siltation (84). Mobile is also studying the possibility of becoming a superport, which would involve magnification of the present problems and would spur onshore development.

Extensive shell dredging is also done in Alabama waters, especially Mobile Bay, causing increased turbidity and loss of oyster setting grounds (1,2).

Dredging problems in Mississippi appear to be confined to maintaining a deep draft port in Gulfport, Mississippi, and to occasional local shell dredging (84).

All types of development are expected to increase in the Florida part of the region. Industrial development is likely to be heaviest near Tampa, but residential and recreational development is likely to be less concentrated and much more extensive (61f,84,100). The mainland coast of Alabama from Gulf Shores eastward has been extensively developed as a residential and tourist community. This has resulted in filling of marshes on the eastern shore of Mobile Bay. The western shore of Mobile Bay contains both residences and industry. Extensive future development of residences and tourist facilities is anticipated (61f).

Heavy industrial and residential development in Alabama has been largely confined to Mobile Bay, where it has produced extensive pollution problems from heavy metals, pesticides, and bacteria sufficient to result in closure of one-third of the bay to shellfishing (1).

The coastline of Mississippi has been more extensively industrialized, and residential and commercial development is widespread. The western half of Hancock County is unsuitable for development, as it is a coastal marsh subject to frequent flooding and is unprotected by seawall. Rebuilding from the ravages of Hurricane Camille is continuing and additional recreational development is anticipated (61f).

Mississippi has numerous point discharges of industrial and domestic pollution, with greater industrialization planned for the future (107).

Damming, dredging, and channelization cause habitat loss, reduction of nutrient and detritus flow, and altered salinities, all of which decrease biological productivity (16).

Physical alterations of bays or upstream tributaries by clearing, ditching, and draining, greatly increase turbidity and siltation, driving out fish and shellfish. Altered salinities result which affect many organisms such as oysters. Lowered pH from introduction of tannins and lignins may also result (16).

The Everglades are unique habitats acutely sensitive to freshwater supplies. Severe curtailment of freshwater inflow can be expected to decrease the overall amount of mangrove and marsh habitat. Moderate alteration would affect the salinities and flushing of these systems causing additional physiological stress on the fauna and lengthening the residence time of pollutants (16,59).

Lower Mississippi Region (08)

Description

The Lower Mississippi Region includes the Louisiana Coast. Louisiana has a Gulf coastline composed of high energy sand beach in the western third of the state and barrier islands in the rest of the state with their associated high energy sand beach, marshes and sounds. The eastern portion of the state is dominated by the deposition of mud and silt occurring on the Mississippi delta, providing a habitat suitable for extensive marshland (61f,84).

The Lower Mississippi Region leads the United States in the production of shrimp, and supports many other important estuarine dependent commercial fisheries, including oysters, crabs, clams, red drum, spotted sea trout, croakers, menhaden, mullet, flounders and catfishes (32,33,61f,84). The area is also vitally important to migratory waterfowl and endangered species such as the Brown Pelican and American alligator (84).

Louisiana (the Mississippi River Delta area) has more estuarine area and marsh than any other state except Alaska. The area also has fish catches exceeding one billion pounds, almost one-third of the U. S. total.

Major estuaries of the region are:

Lake Borgne
Breton Sound system
Mississippi Delta
Barataria Bay
Terrebonne Bay
Caillou Bay
Atchafalaya Bay
Blanche Bay
Vermillion Bay

Problems

Major Concerns:
domestic pollution
draining and filling

Significant Concerns:
commercial fish processing wastes
oil spills
heavy metals
dredging

Lesser Concerns:
electric power expansion

The region is beset with a number of water quality problems. Domestic waste has affected the shellfish industry by forcing closure of grounds due to high bacterial counts. This is a result primarily of poorly treated sewage. Elevated nutrient levels encourage algal blooms generating high BOD. Resultant oxygen lows sometimes cause fish kills (16,32,84,107). Wastes from commercial fish processing plants are also considerable in the region. These discharges threaten the shellfish industry and are expected to increase in the future with population increases (32,61f,84,107,109).

Industrial pollution is primarily from point sources outside the coastal zone proper, except in the Mississippi River which has considerable upstream pollution input. Industrialization is also expected to increase, causing continued problems with acids and heavy metals. The impact is expected to be greatest in the Mississippi delta region (84,107,109).

As industrialization and residential development continue, electric power consumption will continue to increase. The demand is expected to be met with the construction of approximately 20 new power plants (105). Associated problems include increased heavy metal and suspended solid concentrations (19,20).

In the coastal zone proper, oil and sulfur industries threaten productive marshes with oil spills and loss of habitat due to construction and/or seismic exploration techniques (11,57,107).

Industries such as the petrochemical industry discharge heavy metals and acid wastes into the rivers, especially the Mississippi and Calcasieu rivers (107,109).

The petroleum industry in Louisiana is already large and causes problems with acute and chronic oil slicks, injurious to both organisms and habitat. Offshore development threatens to increase these problems and introduce new ones. Offshore exploration, if accompanied by rig and pipeline construction, will alter the circulation of estuaries and temporarily disturb the sediment, increasing turbidity and siltation damaging to all biota, particularly to shellfish. Of greater significance, offshore development will spur onshore development, accelerating loss of marsh habitat (11,16,57,107).

Loss of marsh habitat has also occurred by draining for agriculture and filling for construction. Continued development will result in further loss.

Dredging and channelization have occurred extensively in Louisiana affecting nearly all geological and biological features. Types of environments altered to date include tidal connections with the sea, open bays, oyster reefs, shallow shoreline zones, beaches, tidal flats, submerged aquatic vegetation, marshes, river deltas, and their distributaries. Alterations of any one environment often affects the others through changes in circulation, increased turbidity, and increased sedimentation. Erosion control projects present the same kind of effects. Nevertheless, massive flood control, channelization, dredging, and erosion control projects are scheduled for the future by the Corps of Engineers (16,61f,84,107).

In addition, recent superport studies have approved the construction of a superport between Bayou LaFourche and Southwest Pass. Construction of such a port would require extensive dredging of a channel up to 90 feet deep (31 , 84).

Texas-Gulf Region (12)
(West Gulf)

Description

The West Gulf region consists of the shoreline and coastline of the state of Texas. The Texas coastline is predominantly composed of high energy sand beaches with protecting offshore barrier islands, important as nesting and wintering areas for many species of birds (59,61f).

All Texas estuaries are characterized by year-round high temperatures. Most of these estuaries are characterized by low but extremely variable salinities, shallow depth, and reduced tidal action (15 , 59). Sedimentation, especially from rivers, is pronounced and bottom sediments are generally mud. These are areas of high nutrient input, large expanses of salt marsh, and extensive oyster reefs, resulting in high biological productivity (59 , 84).

Texas also has two semi-landlocked lagoons, Upper and Lower Laguna Madre, characterized by high temperatures and high and variable salinity. These are regions of lowered biological activity (15 , 59). In addition, Texas has one large estuary of low salinity, Sabine Lake, which may become fresh during periods of high freshwater runoff and may become almost completely devoid of marine life.

The Region supports many endangered species, such as the Whooping Crane, Brown Pelican, Peregrine Falcon, red wolf, and American alligator. Thirty-one of thirty-eight bird species listed as endangered in 1968 may be found along the Texas Coast (59 , 84).

The Texas Coast is a large wintering area for waterfowl, and an estimated 78 percent of the world population of Redhead ducks winters in Laguna Madre. Ninety percent of all commercially important species of fish and shellfish spend significant parts of their life cycles in Texas estuaries including menhaden, red and black drum, spotted sea trout, blue crabs, oysters, and penaeid shrimp. Texas accounts for 13 percent of the world shrimp harvest (59 , 84).

All of these systems have various reactions to the stresses made upon them by man's activities.

Major estuaries of the region are:

Sabine Lake
Galveston Bay system
Brazos River
Matagorda Bay
San Antonio Bay
Corpus Christi Bay
Nueces Bay
Baffin Bay
Laguna Madre

Problems

Major Concerns:
domestic sewage and surface runoff
freshwater supply

Significant Concerns:
electric power expansion
industrial expansion
shipping dredging
dredging for pipeline and access to shore facilities

Lesser Concerns:
oil contamination

Present and proposed chemical and physical alterations of Texas estuaries are many and varied.

Pollution from municipal and domestic sewage and surface runoff is a big problem. Sewage facilities are severely overtaxed in recreational areas. Discharge from individual systems, i.e. septic tanks, is undetermined but thought to be substantial. Two-thirds of the 368 wastewater treatment plants in the Texas coastal zone are producing poor quality effluents. Fifteen of 171 domestic solid waste disposal sites are substandard. Surface runoff of heavy metals and pesticides is not quantitatively known but is detectable in many estuarine waters and sediments, and is likely to increase with expanding future developments (59).

Poor waste treatment poses threats to the recreational and shellfish industries (59,107). High bacterial levels make shellfish unsafe for human consumption. This problem is accentuated during periods of high runoff, when shellfishing is often halted until levels are determined to be safe (59).

Organic pollution from urban and agricultural areas increases nutrient levels which cause nuisance algal blooms, and may be responsible for fish-killing red tides. Oxygen demand is also heightened and further lowers biological productivity (59,107).

Electric power generation is expected to increase from 139,010 GWH in 1975 to 301,310 GWH in 1985 to 877,410 GWH in 2000, an increase of six-fold. Nuclear power is expected to supply 75 percent of the total generated in this region by the year 2000. Saline water withdrawal for cooling purposes is expected to increase from 3,054 MGD to 17,067 MGD in the same period (18).

Petroleum and gas are the major industries in the Texas coastal zone and account for 50 percent of the petrochemical and 25 percent of the oil refining capacity of the nation. Acute and chronic oil spills threaten marine life with short and long term effects. Brine discharge from refineries can raise the salinities of estuaries, with subsequent ecological effects (15 , 59). This problem has been recognized and at present there is no discharge of brine into surface waters. Texas reserves are mature, and offshore development is being studied. Offshore development will require pipelines and extensive onshore development involving extensive initial and maintenance dredging, habitat destruction, chronic leaks, and possible massive spills.

Heavy metals and pesticides threaten the fish and shellfish industries by direct kills and production of organisms unsafe for human consumption. These pollutants are concentrated whenever flushing time is reduced, and by canals which act as transport flumes.

Sulfur mining is an important Texas industry. Sulfur occurs within the caprock of salt domes and is mined by injection of hot water to melt the sulfur, which is recovered through return wells. It is used primarily for production of sulfuric acid. Known reserves at present production levels are not expected to last longer than 20 years. Further sources are expected to come from offshore domes (59).

Extensive shell dredging mostly in San Antonio Bay provides a local limestone supplement. This dredging increases the turbidity of the estuary, silts valuable marshland and oyster reefs, and reduces oyster setting. Current Texas reserves are unknown but are expected to be depleted soon at the present consumptive rate (16 , 59).

Paper and textile mills and metal and plastics industries are all located along the Texas coastal zone, but have minor impact compared to the petroleum industry. These industries are sources of BOD, suspended solids, phenols, cyanides, fluorides, ammonia, oils, acids, and metals (59). Extensive new industrial facilities are scheduled for the Corpus Christi area, and a new freon plant is scheduled for Nueces Bay (84,107).

Agriculture is a source of herbicides, insecticides and pesticides, which may arrive in estuaries. These have been found in estuarine waters, but even where they do not occur in the water column, they have been found in the sediment (59).

Feedlot runoff has provided an undetermined, but extensive source of nutrients and bacterial contamination of estuaries. The livestock and poultry industries in the Texas coastal zone account for a substantial portion of the industry in Texas (59).

There are eleven major ports in the Texas coastal zone, handling 90 percent of Texas shipping. The feasibility of offshore terminals and superports is being explored, which involves initial and maintenance dredging and construction of onshore facilities. Superports would involve even larger amounts of dredging, greater support facilities, and greater alteration of circulation patterns. Both Galveston and Corpus Christi have developed 45 foot channels (59).

Texas bays and estuaries have been and will be extensively dredged and channeled for transportation, access canals, and shell dredging. There are 668 miles of transportation canals and 3,120 miles of drainage and irrigation canals at present, and plans are underway for more, particularly in southwestern Texas. The associated spoil from these operations has been used to fill valuable marsh areas in the past. Key Allegro, once a valuable nursery ground for many marine species, has been eliminated by fill. Nearby land reclamation for housing developments has also eliminated valuable habitat. Similar developments are planned for Houston and Galveston. Development has also eliminated a population of sea turtles from Padre Island. Diking and draining of marsh to provide cattle grazing land have occurred on Kamay Island, Matagorda Island, and the Guadalupe delta (59). Land reclamation by filling of bays and marshlands for shorefront development provides sediment for erosion, destroys valuable habitat, and affects the flushing time of estuaries (15,59,107).

Transportation canals, water canals, artificial passes between Gulf and estuary, jetties, piers, groins, and platforms alter the normal circulation patterns of these bays, causing scouring in some areas and depo in other areas. This deposition of silt destroys productive marsh and grass beds and oyster reefs. Artificial passes increase the tidal surge through existing bay-Gulf channels, increasing the vulnerability of the coastline to storm destruction. These canals and passes also require continuous maintenance dredging (16,33,59).

Water supplies are already inadequate for Corpus Christi, and plans are underway for building a reservoir on the Nueces River. Upstream water use has reduced tributary flow to Corpus Christi Bay to a point that this estuary becomes hypersaline most summers. Other dams are planned for the Navidad River, and the Guadalupe and San Antonio Basins. Other sources of fresh water are expected to be derived by diversion and extension of the coastal canals of the Texas water system. These canals require extensive initial and maintenance dredging. Depletion of freshwater aquifers has resulted in land subsidence and saltwater intrusion into remaining aquifer supplies, especially in the Galveston - Baytown area (59).

Reservoir dams built to meet the freshwater consumption needs of the Texas coastal zone, reduce flow into the estuaries, altering their circulation patterns, increasing siltation, and reducing the amount of flushing. Reduction of flushing lengthens the amount of time pollutants remain in the bays and estuaries, aggravating the overall pollution problem.

Sedimentation is naturally rapid in Texas estuaries which receive significant tributary flow and is being increased by man. Central and Southwest estuaries receive little flow and are clear. Residential and industrial development, overgrazing, waste disposal, burning, and dredge spoil deposition threaten acres of marshland and barrier islands. Destruction of marshland increases erosion, shortening the life-span of Texas bays, silts oyster reefs, and threatens shoreline structures with slumping (59).

California-South Pacific Region (18)

Description

The California coast is characterized by small, widely spaced estuaries, except for San Francisco, San Diego, and Tomales Bay. The shoreline is basically resistant rock with 41 percent being rocky headlands and cliffs, 36 percent sand beaches (61i).

Coastal watersheds are short and steep and the continental shelf is narrow everywhere except off of San Francisco Bay where river transported sediments have formed a crescent-shaped shelf.

San Francisco Bay, Tomales Bay, and Bolinas Lagoon are examples of tectonic estuaries called grabens. These are estuaries that have been formed by a fault block subsiding and filling with sea water and receiving land drainage. San Diego Bay is partially enclosed with spits while other small estuaries are enclosed seasonally by bar formation.

Principal estuaries of the region are:

San Diego Bay	Monterey Bay
Mission Bay	Half Moon Bay
Anaheim Bay	San Francisco Bay
San Pedro Bay	San Pablo Bay
Santa Monica Bay	Suisun Bay
Mugu Lagoon	San Joaquin Estuary
San Luis Obispo Bay	Tomales Bay
Morro Bay	Humboldt Bay

The tidal range is approximately five feet and complex ocean circulation patterns exist off the California coast. During the winter, the north-flowing Davisons current predominates inshore and the south-flowing California current offshore. During the summer, coastal upwelling interrupts the Davisons current but brings needed nutrients to the coastal waters (84).

Annual rainfall averages from 10 to 50 inches, south to north. Prolonged summer droughts make the Southern California coasts and land behind them a special problem. Freshwater outflow is too sporadic to allow estuarine development (84).

Waterfowl such as the Greater Scaup, Pintail, Canvasback, Black Brant, Wigeon, Scoter, Ruddy Duck, Snow Goose, Canada Goose, Mallard, and Shoveler need the coastal wetlands and estuaries as wintering grounds. San Pablo Bay is a wintering site for the Canvasback, a species whose numbers are now low. The Mallard, Cinnamon Teal, and Gadwall also breed within this zone. Thirty-three species of shore birds frequent this zone as a resting and feeding area. They join many resident birds such as the Elegant Tern whose nesting colony in San Diego Bay is the only one in the United States. The endangered Light-footed Clapper Rail is present in the southern part of the zone and the endangered California Least Tern is locally common in places. The rare California Clapper Rail and California Black Rail can be found in marshes in the northern part of the zone.

Marine mammals such as sea lions and harbor seals use the bays (San Francisco Bay in particular) as hauling grounds. Porpoises are common throughout the region. Also the gray whale calves in Seammons Lagoon and their migration to and from the lagoon draw thousands of people yearly to watch the spectacle.

Many finfish of the zone rely on the estuaries for passage, breeding, nurseries, or feeding areas. Some of the most important are striped bass, shad, northern anchovy, flounders, smelts, and Pacific herring.

There are a number of endangered or rare animals found in the California coastal zone, including the Santa Cruz long-toed salamander, the Morno Bay Kangaroo rat, and the saltmarsh harvest mouse.

The American Peregrine Falcon population, extinct as a breeding bird east of the Rockies, totaled only 10 birds in 1970. Pesticide contamination of the birds' food chain and human disturbance are cited as two contributing factors that have made its mortality rate exceed its recruitment rate.

Shellfish important to man such as oysters, gapers, little neck clams, bay scallops, cockles, along with numerous species of crabs and shrimp, are found in California bays.

In all, California's coastal zone boasts 108 species and subspecies of mammals, 260 species of birds, 54 species of reptiles and amphibians (12).

Problems

Major Concerns:
landfill for development
siltation
domestic and industrial pollution

Significant Concerns:
electric power cooling water
oil pollution

Lesser Concerns:
non-point source agricultural
nutrient pollution (eutrophication)

Since the turn of the century, the coast of California has been subjected to human pressures and changes. In 1900, there were 381,000 acres of tidal marshes and mud flats in California; now there are only 125,000 acres or a loss of 70 percent of these valuable coastal features.

About 28 million acre feet of sewage is put into California's coastal zone yearly and is impacting some kelp beds in which sport fish reside, driving off these fish (13).

California now has a generating capacity of 27,000 MWE, only 3.4 percent of which is nuclear. In 1990, an estimated 100,000 MWE will be needed of which 49 percent will be nuclear (13). This means that 49 million gallons of water per minute will be required for cooling these plants, and thermal pollution, along with the associated problems of impingement and entrainment, may affect the California coastal zone. Closed circuit cooling may mitigate against these problems but is likely to create other problems related to cooling water discharge.

Oil pollution in California can be classed in two categories: offshore spills that wash ashore and spills within harbors and estuaries.

The offshore spills are due to bilge pumping, accidents, offshore loading, or from the oil platforms. The second category is caused by ships ballasting, collision, or strandings, and pipeline ruptures. In San Pedro Bay alone there were 443 merchant and 390 naval accidents between 1962 and 1969 which released 13,000 barrels of oil within this estuary (13).

The Sacramento, San Joaquin and Santa Anna rivers have the state's most persistent pollution problems because of non-point-source agricultural nutrient inputs (91).

On Anacapa Island, there were 552 nestings of the Brown Pelican in 1970. Out of these, there was one offspring produced. This was due to persistent pesticides which resist degradation and cause the eggshells to be thin. When the parents try to hatch the eggs, their weight easily breaks them (14).

Waterway development not only disrupts habitats that are dredged, but also impacts adjacent habitats by siltation, altering water circulation, and spoils disposal. Southern California alone has lost 90 percent of its wetlands and now has only 8,500 acres left (79). Most of California's present problems revolve around water-oriented housing developments and their associated filling, diking, and siltation. Also, road construction upstream from salmon spawning sites deposits sediments on the necessary gravel substrate impairing fertility. This same type of waterborne sedimentation decreases the amount of light that reaches attached algae (kelp) in the near coastal zone causing deterioration of these environments (79). Domestic and industrial pollution has so degenerated California's wetlands that in 1969 only 1800 pounds of clams were harvested statewide; none were harvested from San Francisco Bay for human consumption due to contamination as compared to 1892 when 2.6 million pounds were harvested in San Francisco Bay alone (13).

Columbia-North Pacific Region (17)

Description

The Washington coast has been much carved, eroded, and reduced to low coastal plains and islands by the weathering of sedimentary rock. The estuaries are greater in number, extend further inland, and are more frequently enclosed by spits than those in the South Pacific zone. The estuaries of Puget Sound and the Columbia River are uniquely different, the Columbia for its quantity and force of outflow and Puget Sound for its complex channels and islands (84).

A total of 13 percent of the 3,026 mile Washington shoreline is wide sandy beaches, two-thirds of which is located in Puget Sound and the Straits of Juan de Fuca (61j).

There are several large estuaries and an extensive fiord system with a combined estuarine area of about 194,000 acres. The 350 mile coastline of Oregon consists of 250 miles of usable beaches and the remaining 100 miles rocky headlands and cliffs. Approximately 43 percent of the Oregon ocean front has sand dune formations (61j).

The Oregon coastal region contains 14 major estuaries including the Columbia River estuary and a number of small estuaries with a combined area of approximately 58,000 acres (53).

Major estuaries of this region are:

Chetco River	Trask River
Rogue River	Wilson River
Coquille River	Nehalem River
Coos Bay	Columbia River system
Umpqua River	Willipa Bay
Smith River	Grays Harbor
Siuslaw River	Quinault River
Alsea River	Strait of Juan de Fuca
Yaquina River	Puget Sound system
Silez Creek	

The entire coast is characterized by the ever-changing cycle of erosion and deposition due to the fact that the tidal force is directed north-northeast almost parallel to the coast.

Even with this geologic turmoil, the estuaries, bays, and marshes of the Columbia-North Pacific Region are a haven for many types of fish and wildlife. All five species of Pacific salmon, steelhead trout, and sea-run cutthroats use the estuary as a passageway from the oceans to their breeding rivers. Many other fish such as shad and herring need these estuaries as nursery grounds for spawning and rearing of young.

Many types of wildlife are found in Oregon's estuaries. Salmon, perch, and flounder are among those species fished for in the bay. Commercial or recreationally important are oysters, soft shell clams, hard shell clams, and butter and geoduck clams. Crabs and shrimp are both abundant and harvested by fishermen. Tillamook Bay in Oregon is the major wintering area for Black Brant; and several species of ducks, geese, and shore birds use these Pacific Northwest estuaries extensively. Also, hard shell clams which are found in the more saline part of the estuary and soft shell clams which are found in the low salinity tide flats are an important commercial and recreation feature of these estuaries (53,84,105).

Great numbers of birds also have need of these North Pacific estuaries. The wintering waterfowl consist of Mallard, Wigeon, Pintail, Green-winged Teal, Goldeneye, Bufflehead, Scoter, Greater Scaup, Snow Goose, Canada Goose, and Black Brant. The nesting and breeding birds are Mallard, Wood Duck, Wigeon, Cinnamon Teal, and Blue-winged Teal. Heron rookeries are also common in this zone and habitat is provided for a great number of shore birds such as the Plover and Sandpiper.

Problems:

Major Concerns:
pulp mill wastes

Significant Concerns:
oil spills
land development
erosion due to reduced sediment transport
filling and sedimentation in Oregon estuaries

Lesser Concerns:
electric power generation cooling water

The Columbia-North Pacific Region is in the enviable position of being able to see what increased industrialization and population density without proper waste treatment can do to water quality while their water remains fairly clear; however, a number of areas in this region are already experiencing problems in their estuaries (52).

Two-thirds of Washington's population live in the northwest and this region of the state is geared for urban, metropolitan, and industrial use. Change from existing primary to secondary treatment plants is necessary just to maintain present water quality. The Columbia and Salmon rivers and Coquille Bay all have major domestic sewage problems.

Requirements for electric power are expected to increase greatly in this region in the next 25 years. The anticipated 1975 electric generation of 11,441 GWH is expected to increase to 66,143 GWH by 1985 and to 234,872 GWH by 2000, an increase of twenty-fold. Hydroelectric power will supply a part of this increase, but the majority will be steam-generated, requiring about 5,900 MGD of saline water for cooling in the coastal area by the year 2000 (18).

The annual reports on oil spills to the Washington House Committee on Ecology indicates an increase from 262 in 1970 to 983 in 1973, a rise of 275 percent. Also reported between 1970 and 1973 was an increase of fish kills of 25 to 38, or 52 percent. Some of the increase can probably be attributed to the surge of public environmentalists being more conscientious in reporting these incidences (91).

Two recent studies, one by Minneapolis Honeywell, the other by the Sierra Club, predict 2.4-4 and 8 bulk cargo ship collisions per decade, respectively, making the possibility of oil spills a significant problem in the region (113).

One of the major pollution problems in Washington is the effluent from the pulp mills in areas such as Bellingham Bay, Everett Harbor, Port Gardner, Port Angeles, Elliot Bay, and Grays Harbor. The BOD loads in some of these waters, especially at times of low water flow, lower dissolved oxygen levels below the 5 mg/l needed for salmon just to pass through these waters. The

Department of Fisheries believes that during the fall the intermittent releases of wastes from Rennie Island above Grays Harbor cause an avoidance reaction that drives the pre-spawning salmon back to the harbor and back to the fishing pressure present there (113).

Industrial wastes greatly affect the viability of the Columbia River, Yaquina, Siuslaw and Umpqua bays, and also Coos Bay where effluent from pulp mills endanger the estuary.

The average surface runoff in the Columbia-North Pacific Region is 278 million acre feet annually, 384,000 cfs. Of this, 74,000 cfs. is inflow from Canada. Chemically the water in this region is suitable for domestic use. The dissolved solid content is usually less than 250 mg/l. Nitrates and phosphates originate from natural and man-made sources and agriculture and cause eutrophication in parts of the Yakima and Snake River basins and areas of the Columbia irrigation project (105).

In Puget Sound the Committee on Ecology also shows concern over planned land development and recreational activities in the San Juan Island and Hood Canal areas (91). These projects will not only remove valuable estuarine areas needed for waste assimilation but will put an added strain on the systems because of effluent input.

In Oregon the major problems in the estuaries appear to be filling for road and land development or increased sedimentation. The drainage basin for the Tillamook Bay was extensively damaged by fires, thereby increasing sedimentation in the estuaries. Siletz Bay has the same increased sedimentation problem but is primarily due to bad land management in the watershed. Nehalem, Netarts, Yaquina, Coos, Coquille and San Lake bays are all in danger due to filling for either land development or new roads (52).

There are four deep draft harbors in the Pacific Northwest area; these are Coos, Yaquina, Willapa bays and Grays Harbor. This depth is maintained for fourteen, two, twenty, and twenty miles respectively. In the Columbia River, which is the second largest river system in the United States, deep draft facilities (40 feet deep and 600 feet wide) are maintained. This project will extend to Vancouver, Washington (106.5 miles) and was 57 percent complete as of June 1972. At the mouth of the Columbia a stabilized entrance channel is maintained 48 feet deep extending 2 miles seaward and 3 miles landward.

Throughout the Columbia-North Pacific Region there are numerous flood control and channel maintenance projects by the Corps of Engineers; however extensive damage by erosion is showing up at different places along the coast due to the entrapment of sediments behind dams, or within estuaries that have been dredged, thereby increasing their trapping ability. The lack of deposition of these sediments to counterbalance erosion in some areas means damaging retrogression of the lands located here.

Alaska Region (19)

Description

The coastline of Alaska is 6,640 miles (10,680 km) long, 54 percent of the total United States coastline. Its coastal systems are very diverse. Bristol Bay, the Yukon River delta, and the Seaward Peninsula have areas that are coastal plain; from Southeastern Alaska to the bight of the Gulf of Alaska the coast is glaciated and the Gulf of Alaska and western coast are resistant rock. The estuaries vary from glacier-fed fiords to large bays such as Bristol Bay to many medium and small estuaries. The watersheds also vary from temperate rain forest to the tundras and glacial terrain of the Arctic. The tide range also varies greatly, from 1 foot off the north slope to 30 feet at Anchorage at the head of Cooks Inlet, more change than any other region (5,84).

Fiords and coasts eroded by past glaciers have an estimated 23,000 miles of shoreline or 68 percent of the total tidal shoreline; wave pounded coasts constitute 19 percent; tide mixed estuaries 2 percent; ice affected coast (bordered by sea ice most winters) 8 percent; ice affected coast (bordered by ice all winters) 3 percent (5).

All reports are adamant in their praise of Alaska's wildlife. Great numbers of waterfowl such as Scoter, Eider, Oldsquaw, Goldeneye, Emperor Goose, Trumpeter Swan, Wigeon, Mallard, Pintail, Bufflehead, Canada Goose, White-fronted Goose, Black Brant, the endangered Aleutian Canada Goose, and Whistling Swan feed in Alaskan estuaries. In all, 219 species of birds occur in Alaska; 111 are water-related.

The combination of the Kuskokwim delta and Yukon delta is one of the most important nesting areas in the North American continent. This area produces an annual fall flight of 2.6 million ducks.

Marine mammals that occur in Alaska's coastal areas are the harbor porpoise, stellar sea lions, northern fur seals, sea otters, walrus, humpback whale, and beluge whale. The ribbon seal and humpback whale are endangered species. Presently there are an estimated 5,000 sea otters in Alaskan waters (84).

Salmon, of course, are the major fish in the Alaskan estuaries. Also steelhead trout, flatfishes, herring, char, smelt, and sablefish combine to make a list of commercially and recreationally important fish.

No adequate data are presently available on different estuarine areas in Alaska; however, there are nine National Wildlife Refuges with a total of 226,500 acres and 1,770 shoreline miles.

Major estuaries include:

Large reticulum of straits, sounds, and channels in Alexander Archipelago of South East Alaska

Cooper River	Kotzebue Sound
Prince William Sound	Bristol Bay
Cook Inlet	Silver Bay
Yukon Delta area	Chiniak Bay
Kuskokwim Delta	Wards Cove
Norton Sound	

Problems

Major Concerns:
pulp mill wastes
fish processing wastes

Significant Concerns:
municipal wastes
potentially - oil spills and contamination

Minor Concerns:
timber leachates and bark

Alaskan waters are pristine compared to the rest of the U.S., but pollution sources in Alaskan estuaries can be classed into five categories; timber industry, pulp and paper, petroleum, fishing, and municipal wastes. A fish kill was reported in Silver Bay due to pulp mill effluent, and Kodiak Harbor fish habitat has been degraded by fish processing plants (97).

The disposal of untreated municipal wastes into the sea is common to coastal cities and villages, and adverse effects have been shown in embayments with restricted circulation. However, as the population of Alaska grows this practice will, of course, have major detrimental effects on water quality, and municipalities are now faced with the requirement of secondary treatment before release (97).

Along with population growth, energy needs will climb rapidly. In 1970, generating capacity was 351 MWE, 50 percent steam generation, 25 percent hydroelectric, and 25 percent diesel or gas turbine (7). The expected capacity in 1975 is 1083 MWE, of which about one-fourth will be fossil steam. Hydroelectric plants are expected to play the major role in increasing capacity to 27,510 MWE by the year 2000, with fossil steam remaining at about 25 percent of total capacity. No nuclear plants are anticipated (18).

The petroleum industry does not significantly pollute Alaskan coastal systems at the present time though there have been repeated oil spills in Cook Inlet. However, when the oil that will be piped from the north slope to Port Valdez via the Trans-Alaskan pipeline has to be tankered out of Prince William Sound, oil pollution may attain significance. The disasterous effects of oil pollution on wildlife and ecosystems are well-documented and stringent surveillance of the petroleum industry should be made to protect Prince William Sound, one of the largest estuarine areas in North America (97).

In 1972 Alaska was fourth in tons of fish landed and processed, and wastes from these plants have already degraded water quality in areas. In Kodiak chitinous skeletons and entrails of crabs and shrimp have always been dumped into Chiniak Bay along side the processing plants. This has led to near bottom anoxia due to accumulated organics and releases of toxic hydrogen sulfide gas (97).

The timber industry is one of Alaska's most important, and will probably remain so. In 1970, 560 million board feet of timber, mostly hemlock, was harvested (97). Water areas are used for log handling and storage, and coastal pollution problems are already apparent in Southeast Alaska. Loss of bark affects the benthic community by measurably increasing the BOD. Leachates (especially from Douglas Fir) have acute toxicity to marine and freshwater fish (66).

The pulp industry wastes at Wards Cove and Silver Bay have seriously degradated water quality because of inadequate treatment according to the Federal Water Quality Administration in 1970 (97). Sulphate waste liquor concentrations, known to be at toxic levels to phytoplankton and salmon food organisms, have been found throughout both these areas. Summer coastal upwelling and the low oxygen waters involved combined with the higher BOD due to waste liquor and solid discharges drive the dissolved oxygen below the minimum (6 mg/L) allowed by the Alaska quality standards (97).

Great Lakes Region (04)

Description

The Great Lakes Region comprises the five Great Lakes, Superior, Michigan, Huron, Erie, and Ontario, and their tributaries and the upper St. Lawrence. Together they constitute the largest body of fresh water in the world (84). The many bays, tributaries, and shoal areas of the lakes function as areas of high biological productivity in a manner analogous to the function of estuaries at the interface of rivers and land with the ocean.

The Great Lakes have insignificant astronomical tides, but have pronounced seiches and considerable wave action. They are rimmed with significant lengths of high energy sand beach, marshland, and both erodable clay bluffs and rather stable rocky bluffs (see Table 1.5).

The Great Lakes fisheries have been considerably impacted by man, but the region still supports a commercial fishing industry and a large sport fishery.

Shoal waters characteristically support beds of submerged aquatic vegetation and where undisturbed, support the important fish of the lakes, including lake trout, rainbow trout, brown trout, brook trout, coho salmon, chinook salmon, kokanee salmon, yellow perch, white perch, northern pike, whitefish, alewives, smelt, lake herring, catfishes, bass, sunfish, burbot, walleye, and carp (24,25,26,27,28).

The Region is extensively used by migratory waterfowl, fur-bearers, and large numbers of other wildlife (61d,82,83,84).

Problems

Major Concerns:
- water pollution
- shoreline erosion (Michigan)
- industrial discharges
  - chlorine
  - acids
  - cyanide
  - phenols
  - oil
  - heavy metals

Significant Concerns:
- overfishing
- power production
  - thermal addition
  - radioactive
- lamprey
- destruction of marsh

Lesser Concerns:
- dredging

Municipal and industrial development and pollution, dredging and construction of navigation channels and harbors, electrical power plant discharges, overfishing, and introduction of exotic fish species have each had a marked impact on the Great Lakes fishery (24,25,26,27,28).

Pesticides and organic pollution from municipal sources sometimes cause direct mortality and lower productivity from increased turbidity, coliform count, and lowered dissolved oxygen.

Electric power in the area is supplied by the operation of 365 generating stations primarily fossil fuel powered. Demand is expected to increase at a compounded rate of 5.3 percent from 1970 to 2020. Nuclear power is expected to play a large role in meeting this demand, increasing the possible exposure to the environment by thermal and radioactive discharges (23).

Power plant cooling water may increase the overall metabolism of the normally cold water lakes, selecting for warm water species and eliminating the salmonids (43). Thermal additions contribute to fish kills, or decreased abundance, and also may affect an organism's behavior, migration, feeding, growth, and susceptibility to parasitism, predation, and ability to withstand toxic effects (16). Chlorine and heavy metals may also be discharged from these plants, further stressing the lakes. Entrainment and impingement at intake canals is said to have substantial impacts on population levels. This may be a concern with endangered species (43).

The Great Lakes support a large number of industries, especially along the Lakes Erie and Ontario shorelines. The country's largest iron and steel industries are located here, as well as pulp and paper mills, mining operations, petroleum refining, chemical and food processing, and canning industries (109,110). These industries introduce large amounts of chlorine, acids, cyanides, phenols, oils, and heavy metals, especially mercury. Discharge of these effluents is often concentrated in harbors and shallow water areas, where fish populations are greatest, and where spawning sites are located (109,110). This has had massive impacts on fish and other organisms, with obvious repercussions for the commercial and sportfishing industries.

Continued industrial and residential development threaten the area with increased organic pollution, heavy metals, and other industrial wastes. Taconite tailings and heavy metal wastes from steel production are big problems unlikely to be appreciably abated in the near future (109). A potential iron-manganese nodule resource exists in the lakes which would involve dredging and sedimentation if and when it is exploited (115).

Completion of the Great Lakes canal and waterway system allowed introduction of destructive fishes such as the sea lamprey and competitive fishes such as the smelt and alewife. Coupled with stresses caused by increased pollution and overfishing, the Great Lakes fishery rapidly declined in each lake, most noticeably in Erie and Ontario. Lake sturgeon became extinct or rare in all lakes before the turn of the century. The open water fisheries for lake trout, ciscoes, and whitefish declined or disappeared around 1940, leaving populations dominated by alewives and smelt. Blue pike and some species of burbot are extinct in some lakes and endangered or extinct in others. Re-stocking with Finger-lakes brook trout, splake (crosses between brook and lake trout), rainbow trout, steelheads, land-locked Atlantic salmon, and kokanee, chinook, and coho salmon is being carried out in attempts to restore some of the fishery (24,25,26,27,28).

Extensive construction of erosion control structures, navigation channels, and harbors has already occurred, and a number of such projects are being studied for the future. In addition, maintenance dredging of existing harbors and channels will be periodically required (84). This results in increased turbidity, lowered dissolved oxygen, resuspension of nutrients and heavy metals through disturbance of sediments, disruption of benthic fauna and flora, and altered circulation patterns. Consequently, productivity is lowered, and the toxic effects of some pollutants may be increased. Dredge spoil from such operations formerly was deposited in productive marsh areas, causing loss or impairment of productive habitat (16,51,89,116). Residential, industrial, and agricultural development in previous years resulted in the loss of extensive acres of marshland through filling and draining. Guidelines and policies of the Fish and Wildlife Service and the National Marine Fisheries Service and regulations of the Corps of Engineers have now eliminated these practices.

Hawaii Region (20)

Description

This island chain is characterized by small estuaries due mainly to the volcanic nature of the islands. The total area of these estuaries, approximately 50 in number, does not exceed 200 km^2 (103). Because of their small size, the ecological balance can be disrupted by relatively small amounts of toxic effluent. Also, since the Hawaiian watershed is comparatively small and the tide range is around one meter, the estuaries flush rather slowly. Pearl Harbor has been shown to have a water residence time up to four days (103).

Biological data are sparse for Hawaiian estuaries; however, a correlation can be drawn between the importance of Hawaiian estuaries and other estuaries of the United States.

Commercially important fish and shellfish are the big-eyed scad, mackerel scad, goatfish, crevalle, Pacific threadfin, oysters, clams, spiny lobster, and octopus.

Nesting waterfowl include the Hawaiian Duck, Hawaiian Stilt, Gallinule, and Coot, while the Pintail and Shoveler are important migrants. The Hawaiian Duck (Laysan Duck) is endangered. Birds such as the Pacific Golden Plover, Turnstone Sanderling, and Tattler feed in the estuarine zone.

Important marine mammals are the Pacific bottlenose dolphin and the rare Hawaiian monk seal.

More complete biological data should be generated within Hawaii's estuaries to monitor future changes in these systems.

Major estuaries include:

Hilo Bay
Pearl Harbor
Kaneohe Bay

Problems

Major Concerns:
domestic waste treatment and drainage
siltation

Significant Concerns:
sugar cane processing wastes
fish processing wastes

Due to the relatively short estuaries and close proximity of the people to the ocean, most water quality problems are marine, although estuarine water quality is affected mostly by sewage effluent, sugar cane processing wastes, and fish processing wastes, along with siltation from housing developments and highway construction. Two coral kills were reported. One was due to sewage in Kaneohe Bay, and the other involved eight acres of coral and was due to thermal effluent from the Kahe power plants on Oahu. Pesticide and oil pollution are both insignificant, but one molasses spill is reported with no reported ecological effects (29).

Future problems appear to revolve around manganese ore processing. There is a possibility of a plant being built in Hawaii using hydrogen chloride leaching, but pilot plants show no water quality degradation associated with the project.

Caribbean Region (21)

Description

The Caribbean Region includes the island of Puerto Rico and the Virgin Islands. The coastline of the island of Puerto Rico is characterized by naturally stressed, low diversity ecosystems, almost evenly divided between rocky cliffs and high energy sand beaches (60). The coastline is indented with coves and small embayments, comprising the bay and estuarine portions of the Puerto Rican shoreline (84). The bay and estuarine shoreline contains some sand beach also, but is dominated primarily by highly productive salt marshes and mangrove swamps. Productive coral reefs and rock islets extend offshore of many bays and much of the coastline (61f).

The Virgin Islands consist of more than 40 islands and cays. The coastline is dominated by rocky bluffs with relatively little high energy sand beach comprising the remainder. The bay and estuarine shoreline is dominated by salt marsh and mangrove swamp with some sand beach. Many productive coral reefs extend offshore and into the bays and lagoons (61f,84).

The productivity of many tropical ecosystems is high due to their high ambient temperatures and relative stability (60). In general, perturbations in any of the tropical systems are likely to decrease their biological productivity.

Major embayments include:

Bahia Sucia	Coral Bay
Phosphorescent Bay	Caneel Bay
Bahia de Guánica	Krause Lagoon
Bahia de Rincón	Limetree Bay
Bahia de Jobos	Manchenil Bay
Laguna San José	Halfpenny Bay
San Juan Harbor	Great Pond Bay
Bahia de Boquerón	Tague Bay
St. Thomas Harbor	Altona Lagoon
Magens Bay	Salt River Bay
Brewers Bay	

Problems

Major Concerns:
waste treatment

Significant Concerns:
sedimentation
dredging

Input of wastes from rivers is derived from over-loaded treatment plants and point discharge sources upriver. This has increased sedimentation, BOD, and coliform counts (107). Sedimentation endangers habitats such as marshes, mangrove swamps, and coral reefs, and organisms such as sessile or slowly-mobile shellfish. High bacterial levels make shellfish unsafe for human consumption, and lowered dissolved oxygen decreases overall biological productivity and may result in fish kills.

Sewage pollution resulting in high bacterial levels in excess of federal water quality standards is occurring in the vicinity of San Juan Harbor. Residential development along the coastline of both Puerto Rico and the Virgin Islands is expected to increase in the near future and may add to or initiate the same problem in other areas (84). These residences may require the construction of erosion protection structures with their associated problems.

Nuclear power plants are in operation in the islands, but the only thermal loading problems at present are caused by industrial operations in St. Croix, Virgin Islands (107). There are no immediate plans for additional nuclear reactors at present, but industrial development is expected to increase somewhat and may add to the thermal loading problem (84).

Air pollution by ethylene from refining operations has been implicated in artificial ripening of mangrove seedlings, reducing their viability. This could reduce the area of growth rate of productive mangrove swamps (88).

Sedimentation is pronounced in many areas of Puerto Rico due to input from rivers. Point discharges of pollutants are a problem in both Puerto Rico and the Virgin Islands, in some cases causing buildup of pesticides and heavy metals at the mouths of rivers (84,90,107).

Dredging operations for boat channels and port facilities increase the turbidity of the water, decreasing the productivity of the plankton community, and increasing siltation destructive to marshlands, mangrove swamps, and coral reefs. Deposition of spoil from such operations also threatens these habitats (16).

The Corps of Engineers has been charged with maintaining channels in various harbors in the islands. Maintenance dredging will be periodically required for port operation.

The increased recreational use of the islands may cause demands for recreational marinas requiring dredging of boat channels and onshore construction of recreational facilities with subsequent habitat destruction or alteration (84).

Residential development of the coastline may necessitate construction of artificial erosion control structures such as seawalls, revetments, bulkheads, groins, breakwaters, jetties, and beach fills (84). The construction, maintenance, and function of these structures involves alterations of circulation patterns, disruption of bottom sediments, increased turbidity and siltation, and loss of habitat (16,59). These alterations are likely to affect the abundance and diversity of organisms present. Residential development may also be a source of organic sewage pollution of nearby estuaries if adequate treatment facilities are not provided.

SHORELINE TYPE

The length of each shoreline type for the WRC regions is summarized in Table 1.5. The classified beaches are described differently in different regions, but are generally rocky or gravel beaches sometimes mixed with sand.

Table 5. Length of Shoreline Types for WRC Regions.

Region	State	Shoreline[1] mi.	Shoreline[1] km.	Coastline[1] mi.	Coastline[1] km.	Estuarine Surface Area acres	Estuarine Surface Area km² [2]	Gravel or Rocky Beach[4] mi.	Gravel or Rocky Beach[4] km.	Sandy Beach mi.	Sandy Beach km.	Unclassified Beaches mi.	Unclassified Beaches km.	Marsh or Mangrove mi.	Marsh or Mangrove km.	Unconsolidated Cliffs mi.	Unconsolidated Cliffs km.	Rocky Shore[4] mi.	Rocky Shore[4] km.
New England	Maine	2,500	4,011.5	228	366.9	39,400	159.4			50	80.5	10	16.1					2,440	3,926.0
	New Hampshire	40	64.4	13	20.9	12,400	50.2					25	40.2						
	Massachusetts	1,200	1,930.8	192	308.9	207,000	837.7			305	490.7	635	1,021.7						
	Rhode Island	340	547.1	40	64.4	94,700	383.2			45	72.4	140	225.3						
	Connecticut	270	434.4			31,600	127.9					145	233.3						
	Total	4,350	6,999.2			385,100	1,558.4					955	1,536.6						
Middle Atlantic	New York	638	1,026.5	127	204.3	376,600	1,524.1					331	532.6						
	New Jersey	469	754.6	130	209.2	778,400	3,150.2			215	345.9			205	329.8				
	Delaware	226	363.6	38	45.1	395,500	1,600.6			76	122.3			100	160.7				
	Maryland	1,939	3,119.9	31	49.8	1,406,100	5,690.5			46	74.0								
	Virginia	993	1,597.7	112	180.2	1,670,000	6,768.5			294	473.0			530	852.8				
	Total	4,265	6,862.3	438	688.6	4,626,600	18,733.4												
South Atlantic-Gulf	North Carolina	3,661	5,890.5	301	484.3	2,206,600	8,930.1			1,269	2,041.8			1,503	2,418.3				
	South Carolina	3,063	4,928.4	187	300.9	427,900	1,731.7			196	315.4								
	Georgia	204	328.9	100	160.9	170,800	691.2			102	163.6								
	Florida	8,426	13,557.4	1,350	2,172.2	1,051,200	4,254.0												
	Mississippi	359	577.6	44	70.8	251,200	1,016.6			1,375	2,212.4[3]			2,423	3,898.6[3]				
	Alabama	607	976.6	53	85.3	530,000	2,144.8												
	Total	16,320	26,239.4	2,035	3,274.4	4,637,700	18,768.4												
Lower Mississippi	Louisiana	7,721	12,423.1	397	638.8	3,545,100	14,346.3			835	1,343.5			1,108	1,782.8				
Texas-Gulf	Texas	1,792	2,883.3	373	600.3	1,344,000	5,438.9			674	1,084.5			359	577.6	421	677.4		
California-So. Pacific	California	3,427	5,514.0	840	1,351.6	552,100	2,234.2	17.5	28.5	622	1,065.6			202	325.8	757.0	1,218.0		
Columbia-No. Pacific	Washington	3,026	4,868.8	157	252.6	193,800	784.3												
	Oregon	1,410	2,268.7	296	476.3	57,600	233.1												
	Total	4,436	7,137.5	453	728.9	251,400	1,017.4												
Alaska	Alaska	33,904	54,551.5	6,640	10,683.8	11,022,800	44,607.1												
Great Lakes	Wisconsin	9,571	15,399.7			10,600	42.9			2,107	416.4								
	Michigan					151,700	613.9												
	Ohio					37,200	150.5												
	New York					48,900	197.9												
	Total	9,571	15,399.7																
Hawaii	Hawaiian Is.	1,052	1,692.7	750	1,206.7														
Caribbean	Virgin Is.	175	281.6	117	188.2														
	Puerto Rico	700	1,126.3	311	500.4														
	Total	875	1,407.9	428	688.6					259	3,390.6								

[1] Data from U. S. Dept. of Commerce, NOAA pamphlet, The Coastline of the United States.

[2] Data, National Estuary Study, Volume 5, U. S. Dept. of Interior, Fish and Wildlife Service, 1970.

[3] Includes Gulf Coasts of Florida, Mississippi and Alabama.

[4] Source Material not sufficiently explicit to classify. Most beaches in these categories as probably shelly, pebbly, or gravel or mixtures.

BIOLOGICAL AREAS

Information is less generally available on the quantity of biological areas except in certain states where such surveys have been tabulated. There is practically no available quantitative information on areas of clam bottoms, scallops, crabs, shrimp, lobster, anadramous fish spawning areas, and nursery areas by species though these are indicated on maps and charts for some states. Reported information is shown in Table 1.6, but blank spaces do not infer a lack of the resource, only a lack of data.

The shortage of available information for oysters and clams, as well as other biological areas, is especially great for the west coast, Alaska, Hawaii, and the Caribbean. Several states are in the process of inventorying intertidal areas and wetlands, but these are incomplete as yet. An example of such an inventory is shown in Table 1.7 for Virginia. Some states have also mapped areas of special significance such as that shown in Figure 1.2, showing spawning grounds of herring in Virginia's Chesapeake Bay tributaries.

Table 1.7. Classification of the Tidal Wetlands of Virginia.

Area	Wooded Marsh	Marsh	Open Creeks	Wood-land	Tidal Flats	Sand	Ponds	Dredged Areas	Temp Lakes	Total
Potomac River	1,790	8,835	6,601		1,123		659			19,008
Rappahannock River	6,689	15,496	10,785	100	722	96	924	11		34,823
York River System	3,083	23,482	5,939	1,134	3,131	169	1,418			38,856
James River	17,676	18,164	7,604	763	3,784	40	638	70		48,739
Eastern Shore Seaside	150	66,435	3,698	66	66,560	4,177	276		389	141,751
Eastern Shore Bayside	139	17,706	12,681		440	9	151			31,126
Chesapeake Bay West Shore	8,681	14,210	12,013	503	3,657	1,524	397	22		41,007
Other	15,080	12,745	1,597	62		1,622	132		374	31,612
Southeast Virginia	6,840									6,840
Totals	60,128	177,073	60,918	2,628	79,417	7,637	4,595	103	763	393,262

Source: Coastal Wetlands of Virginia, by M. L. Wass, T. D. Wright (1969). SRAMSOE No. 10, Virginia Institute of Marine Science.

ENDANGERED SPECIES

The following list gives the endangered fauna for the United States that resides or spends an important part of the life cycle within the estuarine or nearshore marine environment (Table 1.8). The common and scientific names and general location are given. This information is intended to identify endangered species with respective areas that presently receive or are likely to receive significant environmental stress in the near future. In some cases, the endangered fauna receive consideration for listing mainly because of exploitation such as the whales and the alligator.

Table 1.6. Habitat Areas for WRC Regions.

Region	State	Shoal Water acres	Shoal Water km^2	Bays acres	Bays km^2	Salt Ponds acres	Salt Ponds km^2	Warm Clam Flats acres	Warm Clam Flats km^2	Coastal Wetlands acres	Coastal Wetlands km^2	Saltmarsh acres	Saltmarsh km^2	Oyster Bars acres	Oyster Bars km^2	Clam Areas acres	Clam Areas km^2
New England	Maine	39,400	159.4					59,460	240.6	28,882	116.9	17,633	71.4				
	New Hampshire	12,400	50.2	3,900	15.8			12,860	52.0	5,910	23.9	5,675	22.9				
	Massachusetts	207,000	837.7			382	1.5	28,000	113.3	44,695	180.9	42,460	171.8	1,292	5.2		
	Rhode Island	94,700	383.2			6,845	27.7	50,933	206.1	2,050	8.3	2,005	8.1	ND	ND		
	Connecticut	31,600	127.9					71,414	289.0	11,544	46.7	8,986	36.4	ND	ND		
	Total	385,100	1,558.4					222,667	901.0	93,081	376.7	76,759	310.6				
Middle Atlantic	New York	376,600	1,524.1			6,000	24.3			32,395	131.1	26,759	147.1	ND	ND		
	New Jersey	778,400	3,150.1							215,760	873.2			60,000	242.8	301,000	1,218.1
	Delaware	395,500	1,600.5							109,448	442.9			20,000	80.9	15,000	60.7
	Maryland	1,406,100	5,690.3							183,860	744.1			326,000	1,319.3	250,000	1,011.7
	Virginia	1,670,000	6,758.3							197,250	798.2			384,000	1,554.0	300,000	1,214.1
	Total	4,626,600	18,723.3							738,713	2,989.5						
South Atlantic	N. Carolina	2,206,600	8,929.9							191,650	775.6			200,000	809.4	100,000	404.7
	S. Carolina	100,000	404.7							514,400	2,081.8			20,000	80.9	2,000	8.1
	Georgia	170,800	691.2							390,150	1,578.9			15,000	6.1		
	Florida	ND															
	Mississippi	ND															
	Alabama	ND															
Lower Mississippi	Louisiana	ND												583,971	2,363.3		
Texas-Gulf	Texas											488,128	1,975.4				
California-So. Pacific	California	ND						56,205	227.4			48,477	196.2				
Columbia-No. Pacific	Washington	ND															
	Oregon	ND															
Alaska	Alaska	ND															
Great Lakes	Wisconsin	ND															
	Michigan	ND															
	Ohio	ND															
	New York	ND															
Hawaii	Hawaiian Is.	ND															
Caribbean	Virgin Is.	ND															

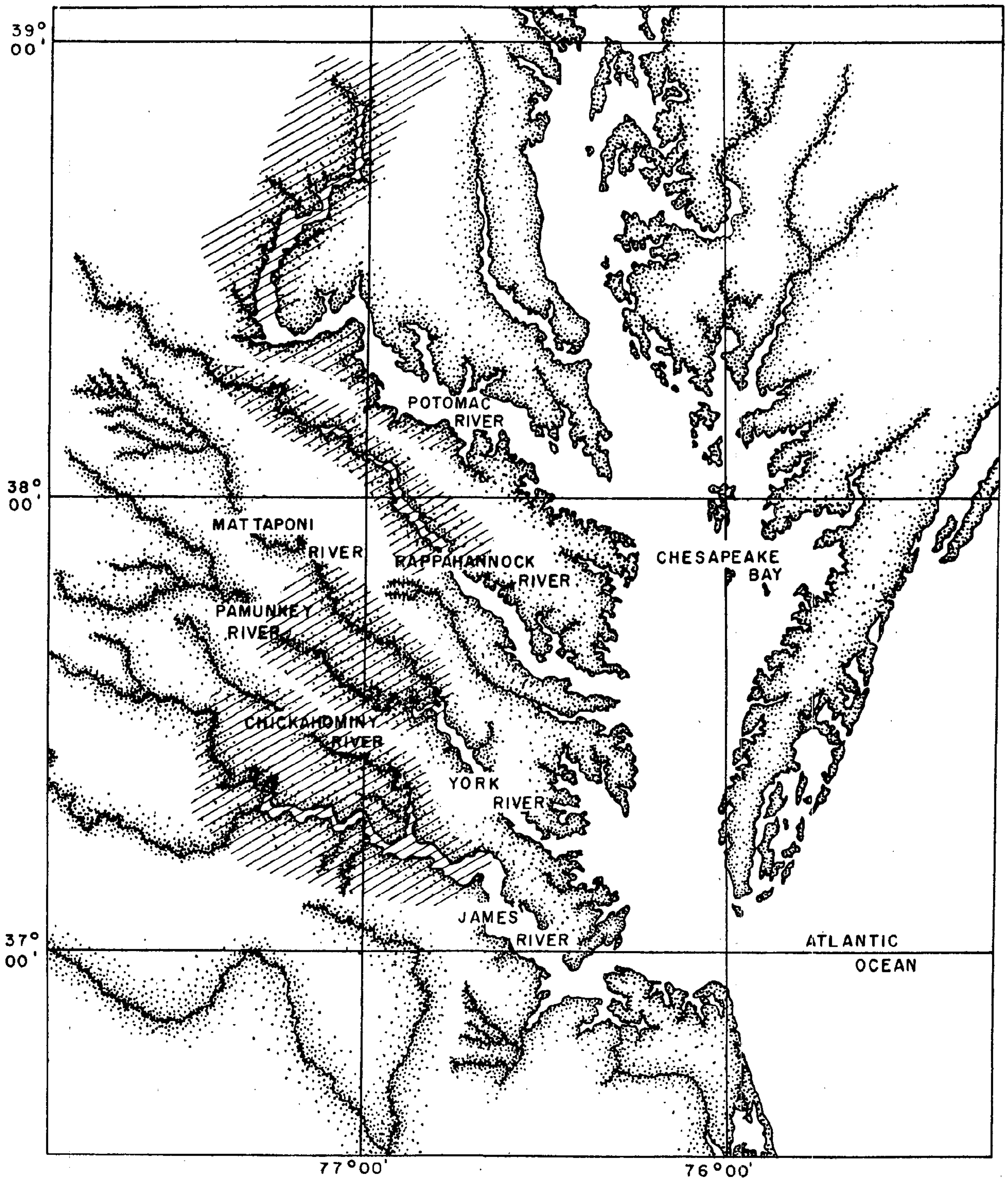


Figure 1.2. Spawning grounds of herring in Virginia's Chesapeake Bay tributaries. Source: Coastal Wetlands of Virginia, by M. L. Wass, T. D. Wright (1969). SRAMSOE No. 10, Virginia Institute of Marine Science.

It is clear that the list is relatively short which may reflect that most endangered species are presently associated with habitats other than the estuarine and nearshore environment; however, the list is continuously updated and more forms likely will be added in the future.

Some species are not year-round residents of the estuarine and nearshore marine area. Most whales are probably only infrequent visitors to this area, except the gray whale, which makes along-shore breeding migrations on the west coast.

Table 1.8. Endangered Species of the Estuarine and Nearshore Marine Environment.

Common Name	Scientific Name	Where Found
Sturgeon, Shortnose	Acipenser brevirostrum	USA/Canada: Atlantic Coast
Turtle, Hawksbill	Eretmochelys imbricata	Tropical seas worldwide
Turtle, Leatherback	Dermochelys coriacea	Tropical and temperate seas worldwide
Alligator, American	Alligator mississipiensis	USA/Southeast
Albatross, Short-tailed	Diomedea albatrus	USA (Aleutian Islands)
Petrel, Hawaiian Dark-rumped	Pterodroma phaeopygia sandwichensis	Hawaii
Pelican, Brown	Pelecanus occidentalis carolinensis	USA (Southeast)
Pelican, Brown	Pelecanus occidentalis californicus	USA (West)
Duck, Laysan	Anas laysanensis	Hawaii
Goose, Aleutian Canada	Branta canadensis leucopareia	USA
Eagle, Southern Bald	Haliaeetus leucocephalus leucocephalus	USA (South of 40th Parallel)
Falcon, American Peregrine	Falco peregrinus anatum	USA
Falcon, Arctic Peregrine	Falco peregrinus tundrius	USA
Crane, Whooping	Grus americana	USA
Rail, California Clapper	Rallus longirostris obsoletus	California
Rail, Light-footed Clapper	Rallus longirostris levipes	California
Tern, California Least	Sterna albifrons browni	USA
Sparrow, Cape Sable	Ammospiza maritima mirabilis	Florida
Sparrow, Dusky Seaside	Ammospiza maritima nigrescens	Florida
Kangaroo Rat, Morro Bay	Dipodomys heermanni morroensis	USA (California)
Mouse, Salt marsh harvest	Reithrodontomys raviventris	USA (California)
Whale, Blue	Balaenoptera musculus	Oceanic
Whale, Bowhead	Balaena mysticetus	Oceanic
Whale, Finback	Balaenoptera physalus	Oceanic
Whale, Gray	Eschrichtius gibbosus	Oceanic
Whale, Humpback	Megaptera novaeangliae	Oceanic
Whale, Right	Eubalaena spp. (all species)	Oceanic
Whale, Sei	Balaenoptera borealis	Oceanic
Whale, Sperm	Physeter catodon	Oceanic
Wolf, Red	Canis rufus	USA (Texas, Louisiana)
Manatee, West Indian (Fla.)	Trichechus manatus	Caribbean/Adjacent Atlantic Coastal

Source: List provided by Biological Service, U. S. Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C.

CHAPTER 2
THE STATUS OF ESTUARIES AND ESTUARINE MANAGEMENT IN THE LEGAL-INSTITUTIONAL SYSTEM

P. A. Dales, III, M. T. Jacks, J. H. Klein

INTRODUCTION

Estuaries as biological entities know no political boundaries, yet they suffer management problems in terms of the activities of the political subdivisions encompassing them. Presently, there is no single locus within the legal system for their management, and, with the exception of the Estuarine Areas Act and administrative policies on wetlands, most regulation and coordination programs have only incidental application to estuarine zones (93). The main purpose of most legislation is to protect a natural resource value incidental to or comprising only a contributing part of an estuary as a dynamic system. The Fish and Wildlife Coordination Act, the Oil Pollution Act, and the Federal Water Pollution Control Act exemplify such an approach to the management of estuarine resources.

THE STATE-FEDERAL RELATIONSHIP

The estuary is a geographic-hydrologic entity laboring within the legal system as the tangential beneficiary of some legislation and comprehensive planning. At present, beyond some benevolent Federal policy statements, estuaries and their welfare are the province of the States. This, of course, is a corollary of a desire to maintain a federalist system of government. In the estuarine zone, the philosophy that individuals and local interests should be assured freedom of choice and freedom from central control is tested against a highly vulnerable and highly valuable array of public resources. Responsibility in this zone is definitely but indistinctly divided between Federal and State sovereignties (84, Vol. I).

The estuary is a zone of land-water interaction. At the water's edge, a mixture of public and private ownership exists, and Local, State, and Federal jurisdictions are superimposed. Submerged lands are, in most cases, State-owned, overlaid with the Federal navigational servitude. Estuarine management encompasses a wide spectrum of control ranging from local planning and zoning to clear Federal regulation. It is because of this framework that most Federal legislation affecting estuarine areas has a single thrust—to encourage States to develop balanced management processes for their estuaries and to require Federal agencies conducting activities in these areas to consider State policies relative to the management of estuarine resources (93).

A prime example of such Federal legislation is the Coastal Zone Management Act of 1972, perhaps the single most important tool in the realm of effective estuarine management. This law authorized the Secretary of Commerce to make grants to coastal states to assist in planning for and administering sound management programs for the coastal zone. Its basic approach is that decision making on the use of the coastal zone, which by definition encompasses the estuarine zone, is primarily a State prerogative subject to Federal jurisdiction in such areas of overriding national concern as water quality standards and energy production. In addition to addressing the broad concept of coastal zone management, the act also specifically recognizes the importance of estuaries by providing for the establishment of estuarine sanctuaries. Thus, while many Federal statutes contain planning and coordination mandates, the Coastal Zone Management Act represents a major piece of Federal legislation providing for and encouraging specific State management responsibilities in estuarine areas.

There can be no doubt that, under the Constitution, the Federal government and the individual States share concurrent jurisdiction over coastal waters; but since State interests are subject to divestiture, Federal and State interests are not co-equal (49). The Commerce Clause, which grants the Federal government the authority to control navigable waters in the interest of commerce[1], and national security interests are examples of grounds on which divestiture can be justified. In addition, large areas of the coast have been developed and are administered by Federal agencies. Even excluding military areas, there are forty areas operated by the National Park Service and ninety-one areas maintained by the National Wildlife Refuge System (39). As the public need changes, so does the law regarding use of public and private property. The law must meet the demands of society—demands in relation to estuaries which may become more readily perceived in the future.

Estuaries lie across the imaginary boundary between proper exercise of Federal regulatory power under the Commerce Clause and the power of the States as the principal inheritors of sovereignty to protect the public health, safety, and welfare through the exercise of their police powers. Beginning with fisheries regulation and continuing through the Submerged Lands Act, acts concerning water quality control, and the Coastal Zone Management Act, Congress has indicated that it considers it to be in the public interest for the States to manage and conserve their own natural resources. Although Congress has had to provide incentives for State action, the States, being the repositories of the police power[2], have a more direct capability to shape the development of estuarine areas than does the Federal government. As a result of these factors, Federal initiatives have been aimed at strengthening State and regional capabilities in the area of estuarine management and making the Federal bureaucracy responsive to environmental issues.

An observation made five years ago in the National Estuary Study is still applicable today and that is, for reasons that are viewed as legitimate by residents, local jurisdictions will not, perhaps cannot, commit

[1]Art. 1, §8, U.S. Constitution.
[2]Tenth Amendment, U.S. Constitution.

substantial land and water resources to the production of values realized by society at large. Additionally, there is no reason to assume that a mosaic of State development plans would correspond to a plan which would best serve even regional interests. Many States now have super-agencies handling conservation and development of natural resources with regulatory structures superimposed over local planning and zoning structures.

Considering the multifaceted format of management, a major problem seems to be the inadequate procedure for reviewing major Federal projects. There is no arbiter to resolve differences arising between various agencies and there are no executive guidelines for actually reviewing major projects (96). As a result, through negotiation, an interagency agreement on a project is reached, but this is often an exercise in finding middle ground which may or may not represent the public interest, since each agency must consider its own constituency which does not necessarily represent the public at large (96). There is simply no controlling statement to be made concerning the balance which must be achieved between conservation and development of renewable and nonrenewable resources and their relative priorities. This is an important factor considering that each Federal agency operates under laws developed by particular Congressional committees to serve specified needs, and private groups representing special interests often influence agency and Congressional action (84). Policy and practice are not necessarily parallel.

The State level of involvement needs to be strengthened, and a clear forum for coordinating specific estuarine-related management functions of different agencies needs to be provided. Although Federal funding has definitely strengthened State estuarine-related management programs, particularly with regard to planning for pollution abatement, fisheries management, resource identification, comprehensive planning, and land acquisition, problems still exist. Due to the great number of agencies, committees, and coordinating groups dealing with activities affecting estuaries, effective coordination and management is difficult. State coastal zone management initiative is competing with the more established agencies and policies such as the Department of Interior, energy related programs, outer continental shelf development, and deep water port development.

Estuaries are transpolitical entities; accordingly, the interstate-regional components of planning should be given more than "required consideration" status in State or Federal planning activities. In fact, the appropriateness of an interstate compact can stem from either the fact that an estuary lies in two states or that a river rises in an inland portion of one state and flows through one or more other states before reaching the sea. It would appear necessary in either case to control communities on either side of a state line by a legal entity which can operate on behalf of the public bodies which normally function under the laws of a single state (84). There is no single locus in the system responsible for estuarine management, and unless there is a pre-emptive national policy, as in the case of navigation or water quality, the States' perception of estuarine management must prevail. Of course, the State perception of management is shaped by pressures on a project-by-project basis (93).

Each major Federal project must be preceded by an Environmental Impact Statement (EIS) under the National Environmental Policy Act. However, the agency required by law to advance the project is also responsible for the preparation of the EIS and must respond to pressures for development and protection—a sometimes untenable internal conflict, particularly without guidelines for interagency resolution of conflicts. Should an agency be the arbiter in its own case? Because of the duties incumbent upon various agencies to advance and protect their own specific interests, interagency conflicts will necessarily arise and, at present, there exists no forum for resolving such differences of opinion. The solution should be neither political nor single project oriented (96), as it now appears to be.

COMPONENTS OF ESTUARINE IMPACT

The majority of the impacts of human activities on estuaries may be divided into four, often interrelated components: a land use and development component, a water quality and water quantity component, a marine transportation component, and a fisheries management component. Each may support Federal regulation over estuary-related activities, but at present the states also exercise various degrees of competence in these areas. It should be remembered, of course, that Federal activity in a particular field does not necessarily preempt parallel State legislation. Florida's Oil Pollution Liability legislation[1], upheld in Askew v. American Waterways Operators, Inc., is an example of this phenomenon[2].

Activities affecting marshes, wetlands, and estuaries are being monitored closely by Federal agencies. These areas are all associated with bodies of water that are considered navigable and, as such, could support Federal regulatory jurisdiction under the Commerce Clause of the Constitution. A multitude of conditions may affect commerce; therefore, this constitutional power affords a considerable legal base. To the extent that estuaries are used as ports for commerce or otherwise in connection with navigation, Federal law may be made directly applicable. In addition to the Commerce Clause, there is the admiralty jurisdiction clause[3], the war grants clause[4] which establishes justification for involvement of the Army in supervision over all improvements made in navigable waters, the property power[5] for management of Federal property, and the treaty power which makes international arrangements affecting estuaries the law of the land[6]. It must be remembered, however, that

[1]Fla. Stat. Ann. § 376.02 (1974).
[2]411 U. S. 325 (1973).
[3]Art. 3, § 2, U. S. Constitution.
[4]Art. 1 § 8, U. S. Constitution.
[5]Ibid.
[6]Art. 6, U. S. Constitution.

what is theoretically possible may not be politically feasible. The States, as the principal inheritors of the rights of sovereignty and the repositories of the police power under the Tenth Amendment, are enabled to act on behalf of the States in matters pertaining to health, safety, and the general welfare as long as such power has not been specifically delegated to the Federal government.

In recognition of this Constitutional arrangement and the power under the Commerce Clause, Congress has granted much authority to executive agencies to deal with specific resource management activities. Executive orders, guidelines developed in connection with administration of particular statutes, and regulations implementing and elaborating acts of Congress provide the remainder of the Federal legal setting for handling estuarine problems. Federal policy more directly affecting estuaries may be found in the National Environmental Policy Act (NEPA), the Estuarine Areas Act, the Water Resources Planning Act, the Fish and Wildlife Coordination Act, and the Coastal Zone Management Act. Each affects a different aspect of estuarine activity. NEPA directs that, to the greatest extent possible, the policies, regulations, and public laws of the United States shall be interpreted and administered to reflect the purposes of the act, insuring that environmental amenities and values will be given appropriate consideration in the Federal decision making process. It follows that any Environmental Impact Statement required by a Federal activity as well as any lesser Federal activity such as permitting procedures are required to consider the policy of the Estuarine Areas Act to protect, conserve, and restore the nation's estuaries in a manner that will maintain a balance between national needs for protection of such natural resources and the need to develop these estuaries to further the growth and development of the nation. In addition, the Water Resources Planning Act is designed to encourage the conservation, development, and utilization of water and related land resources on a comprehensive and coordinated basis. Under the Coastal Zone Management Act, the Congressional policy is to preserve, protect, develop, restore, or enhance the nation's coastal zone resources, of which estuaries are a large part. Both the Estuarine Areas Act and the Coastal Zone Management Act speak of the responsibility of the States to protect, conserve, and restore the estuaries. Consequently, the importance given to estuarine resources in coastal planning processes is essentially a State value judgment and, unless there is a pre-emptive national policy, as in the case of water pollution, the States' perception of estuarine management must prevail (93). Virtually all coastal States are presently involved in developing coastal zone management programs under Federal guidelines, and after implementation of the State programs, the Federal government must generally conduct its programs and activities in accordance with the approved State management programs. The recently passed Deep Water Port Act, providing for adjacent State approval of deep water port development, signifies continued Congressional recognition of the importance of State involvement.

In terms of the land use and development component of estuarine management, the Coastal Zone Management Act is the only Federally-approved land use program. (Note: Section 702 of the Housing Act provides for comprehensive planning grants which undoubtedly include cities situated on or near estuaries, but land uses under the Coastal Zone Management Act are limited to those having a direct and significant impact on coastal waters.) This law provides the opportunity for the States to become a major coordinating body if they satisfy Federally required elements of planning and balancing environmental protection and economic development. Nothing in the Act, however, requires that a completely coordinated system be developed. No other jurisdictional responsibility of Federal or State agencies is diminished and no other coordinating requirements are superceded. Should serious disagreement occur between a Federal agency and a State, the issue is to be mediated in cooperation with the Executive Office of the President. Land use above mean high water remains basically within the purview of the States and is determined within the framework of State law by the interaction of private interests and local governmental policies.

The water quality component of estuarine management includes significant Federal agency activity. Rivers carry large loads of pollutants into estuaries and, since estuaries often have poor flushing characteristics, information regarding pollution loads and carrying capacities is of significant value in estuarine management. The Environmental Protection Agency is the primary Federal agency responsible for water pollution control. The 1972 Amendments to the Federal Water Pollution Control Act (FWPCA) mandate that Federal standards be developed for all discharges and effluents. The several States may implement these standards. The National Pollutant Discharge Elimination System envisioned under this Act is presently being implemented on a state by state basis. The Act, by providing for definitive standards and goals encompassing all of the Nation's navigable waters, covers all point sources of effluent discharge and all vessel discharges except oil (42), which is covered by the Oil Pollution Act. Currently, regulations promulgated under this law by the Environmental Protection Agency and the Army Corps of Engineers, including the various permit procedures under the FWPCA and the Rivers and Harbors Act, extend Federal water quality standards into wetlands areas; consequently, any Federal or State permits for alterations in wetlands areas must now be evaluated in terms of their effect on water quality, a procedure which has withstood judicial challenge[1]. Finally, under the FWPCA, a continuing study of estuarine areas is mandated.

There are several difficulties in the present arrangement. First, the States themselves may become the lead permitting agencies under the FWPCA program, and secondly, certifications of water quality conformity must be coordinated between State agencies, EPA, Fish and Wildlife Service, and the Corps of Engineers. The priority of this requirement among the many duties of each agency is not necessarily high. Third, the problems of siltation and erosion are spread among at least three Federal agencies: the Soil Conservation Service of the Department

[1]U.S. v. Holland, 373 F. Supp. 665 (M.D. Fla. 1974).

of Agriculture, the Corps of Engineers, and the Bureau of Reclamation of the Department of Interior. Heavy and rapid rates of urbanization and highway, commercial and industrial contruction, coupled with monitoring and control difficulties, have increased the flow of sediment from rivers into their estuaries. Complementary laws like the Oil Pollution Act, the Ports and Waterways Safety Act, the Environmental Pesticide Control Act, and the Marine Protection, Research and Sanctuaries Act (Ocean Dumping Act) provide vehicles for protection of the nation's estuaries against pollution by maritime traffic, pesticides, and ocean dumping.

Turning to the water quantity aspect of this component of estuarine resource management, the Water Resources Council, under the authority of the Water Resources Planning Act, directs and coordinates the Federal-State comprehensive planning for the use and development of the water and related land resources of the nation's river basins. Planning under WRC guidance specifically encompasses estuaries and estuarine related resources. The WRC has divided the United States and its territories into twenty-one Water Resource Regions, eleven of which contain estuaries: New England, Middle Atlantic, South Atlantic-Gulf, Lower Mississippi, Texas-Gulf, California-South Pacific, Columbia-North Pacific, Alaska, Great Lakes, Hawaii, and the Caribbean.

Regional and interstate arrangements are an important aspect of estuarine resource management. Of importance to the New England Region is the New England River Basin Commission, an Interstate Water Pollution Control Commission, a Regional Commission under the Public Works and Economic Development Act, and the Atlantic States Marine Fisheries Commission which embraces all the states of the Atlantic Seaboard. In the Middle Atlantic Region, New York alone participates in an interstate port authority, an interstate transportation agency, and an interstate park commission in addition to its own regional water pollution control agency, a metropolitan regional council, and a waterfront commission. Elsewhere in the Middle Atlantic Region there is the Delaware River Basin Commission, the Delaware River Port Authority, the Lower Delaware River and Bay Authority, the Susquehanna River Basin Commission, and the Potomac River Basin Commission. The Coastal Plains Regional Commission, established under the authority of the Public Works and Economic Development Act, operates in the South Atlantic-Gulf Region. In the Great Lakes Region, there is the Great Lakes River Basin Commission, the Great Lakes Basin Commission under the Public Works and Economic Development Act, an International Joint Commission, and the Great Lakes Fisheries Commission. The Pacific Northwest River Basin Commission operates in the Columbia-North Pacific, and the Pacific-Southwest and the Southeast Basin Interagency Committees operate in the California-South Pacific and South Atlantic-Gulf regions, respectively (101).

The above list exemplifies the wide breadth of interests in activities having an effect on estuarine management and the resulting difficulty in coordinating the activities of functioning bodies within these areas.

Under the Water Resources Planning Act, the WRC is primarily riverine and water quantity oriented; that is, it is concerned with determining the adequacy of supplies of water to meet the requirements of the nation (84, Vol. 6). The River Basin Commissions established under its authority, however, do comprehensive planning and conduct research activities directly related to estuarine protection. The River Basin Commissions' plans are reviewed by the Council with special regard to the efficacy of such planning in achieving optimal use of water and land resources in the given area and the effect of the plan on the achievement of other nation-wide programs for the development of agriculture, energy, industry, recreation, fish and wildlife, and other resources.

The Water Resources Council, serving as the principal agency for the coordination of Federal, interstate, State, local, and non-governmental plans for development of water and related land resources, has promulgated regulations with principles and standards for water and related land resources in order to guide other Federal agencies in determining whether a project is in the public interest[1]. These regulations require a balanced consideration of all relevant public objectives, including those of environmental quality, recreation, and fish and wildlife, in all comprehensive planning which the Council coordinates.

The Water Resources Council and its Commissions enjoy authority to plan in estuarine areas. The official position of the Council is that the "use, preservation or development and management of coastal, lake, and river shorelines, islands and estuaries are to be given full consideration in the planning of water and related resources" (84). There are presently six river basin commissions, three of which include estuarine areas. These are the Pacific-Northwest, the Great Lakes, and the New England River Basin Commissions. Two WRC interagency committees function in the Pacific Southwest and Southeast Basins, but the New Jersey coast, the lower Chesapeake Bay, and the Texas-Louisiana coast have no regional planning authorities operating in those areas. The Commissions are instructed to prepare and keep up-to-date comprehensive and coordinated joint plans for Federal, interstate, State, local and non-governmental development of water related resources, which must include an evaluation of all reasonable alternative means of achieving optimum development of water and related land resources of the basin or basins. The New England River Basin Commission has conducted extensive research with respect to estuarine and coastal pollution problems through coordination of research and educational activities, although it has no specific management role. The same is true of the Pacific-Northwest Commission and the Great Lakes Commission. The other interstate groups are of an advisory and coordinating nature and influence management of estuaries only through persuasion (101). An example is the Coastal Plains Regional Commission in the South Atlantic-Gulf Region which contributes to estuarine management primarily by supporting research activities. The authority and responsibility of the Water Resources Council are set forth in Table 2.1.

[1]38 Fed. Reg. 24778 (1973)

Table 2.1. Provisions of the Water Resources Planning Act (42 U.S.C. 1972 (1970)).

Water Resources Planning Act

Title I	Establishes Water Resources Council and sets forth Council responsibilities.
Title II	Authorizes the establishment of River Basin Commissions through the Water Resources Council.
Title III	Provides financial assistance to states to increase their participation in coordinated planning for the nation's water and related land resources.

Water Resources Council

Members:	Secretary of the Interior Secretary of Agriculture Secretary of the Army Secretary of Health, Education and Welfare Secretary of Transportation Chairman, Federal Power Commission
Associate Members:	Secretary of Commerce Secretary of Housing and Urban Development Administrator, Environmental Protection Agency
Observers:	Director, Office of Management and Budget Chairman, Council on Environmental Quality Attorney General Chairmen, River Basin Commissions Administrator, Tennessee Valley Authority Chairmen, Water Resources Council Interagency Committees

Water Resources Council Responsibilities

1. Assess adequacy of water supplies in each water resource region of the United States.
2. Maintain a continuing study of the relation of regional and river basin plans to the water requirements of the nation as a whole.
3. Assess adequacy of administrative and statutory means for coordination and implementation of water and related land resources policies and programs of Federal agencies.
4. Determine principles, standards, and procedures for Federal participation in the preparation of comprehensive regional and river basin plans, and the formulation and evaluation of Federal water and related land resources projects.
5. Responsibilities regarding creation, operation, and termination of Federal-interstate river basin commissions, receiving plans from them, and transmitting these, with recommendations, to the President.
6. Administer grants to the states under Title III of the Water Resources Planning Act.

In addition to the Commissions established under the aegis of the Water Resources Council, there are also river basin and other interstate organizations formed directly by the states involved and the Federal government. In the Middle Atlantic Region, these include the Delaware River Basin Commission, the Susquehanna River Basin Commission and the Potomac River Basin Commission. Interstate compacts in general are constitutionally authorized instruments and are enforceable contracts between the member states, and are interpreted as law in all of them. The Delaware Compact provided for an estuary study, the setting of water quality standards, and a determination of the feasibility of Commission operation of liquid waste collection and treatment systems for the river area. It subsequently established water standards and planned regional waste treatment facilities. It also has regulatory authority which may be exercised independently of the constituent governmental entities. The Susquehanna and Potomac River Compacts were modeled after the Delaware Commission, but provide for specific consideration of environmental amenities. Thus, these three river basin commissions have the jurisdictional authority tc consider estuaries in a broad comprehensive manner, but only the Delaware Commission has the capability to enforce management regulations.

Two other interstate compacts of note are the tri-state compact between New York, New Jersey, and Connecticut which establishes the Interstate Sanitation Commission for the Hudson and its adjacent coastal waters, and the New England Interstate Water Pollution Control Commission. The latter created a single interstate district for an entire region including the coastal waters of Maine, New Hampshire, Massachusetts, Rhode Island, and parts of Connecticut and New York. All estuaries in those states are covered by the compact. Each State must adopt and enforce commission-issued standards and the commission may issue administrative abatement orders and initiate enforcement activities in some of the party States. The Interstate Sanitation Commission sets water quality requirements which it may enforce in court and provides planning for the area. It has measured the assimilative capacity of the tidal waters to provide a sound technical basis for abatement orders and its enforcement capabilities parallel those of participating state agencies (84).

A water system of significant proportions which is excluded from comprehensive planning is the Everglades and the estuaries of Florida Bay, where it would appear that there is significant national interest beyond the purview of State and local governments which would require Federal-State coordination of activities concerning water flow continuity.

Concluding the comments on this component of water quality and quantity, it is important to note that, aside from the independent interstate compact commissions, the jurisdiction of the Water Resources Council and its Commissions does not extend to implementing plans that are developed. The Council is one step removed from the actual conduct of intergovernmental relations in planning for estuaries. It does conduct basic studies into regional water use, quality, and demand, but its principles and procedures are to guide and coordinate other Federal personnel whose actions most directly affect Federal estuarine management programs.

The primary Federal agency operating in estuarine areas within the marine transportation component is the U. S. Army Corps of Engineers. With respect to most activities affecting wetlands, primary jurisdiction lies with the Corps of Engineers under the Rivers and Harbors Act of 1899. Any local government or private entity wishing to perform work (shoreline protection, harbor development, obtaining access to navigable waters, drainage, dredging, etc.) must apply to the Corps of Engineers before that work may begin. This authority is derived constitutionally from the war powers and the Commerce Clause. Once a review process solely concerning effects on navigation, it has now evolved substantially to include environmental protection (96). First, the Corps must consider the policy of the Estuarine Areas Act, which requires all Federal agencies to give consideration to estuaries and their natural resources, and requires Public Works Projects performed by the Corps or any agency to contain in their plans and reports a discussion by the Secretary of the Interior of the estuary involved and the effects of the project on its resources.

Secondly, the Fish and Wildlife Coordination Act requires the Fish and Wildlife Service and the chief official of the State resource agency concerned with fish and wildlife resources to provide the Corps with their comments on the effect of the proposed project on such resources. These alone can form the basis for permit denials, compromises or imposition of mitigating features, a ground affirmed by the courts in the case of Zabel v. Tabb[1]. Guidelines have been promulgated by the Fish and Wildlife Service to assist field personnel in reviewing applications for Corps permits[2].

Thirdly, under the Federal Water Pollution Control Act and, ultimately, under the Coastal Zone Management Act, the Corps of Engineers must receive a certification from EPA or the State that the proposed project or activity will not adversely affect water quality and that it conforms to the coastal zone management program.

The Ocean Dumping Act and the FWPCA require the Corps to apply EPA standards and criteria in approving disposal of dredge spoil materials in oceans or in navigable waters. In addition, the Corps considers the guidelines developed by the Water Resources Council in determining whether projects are in the public interest[3].

Consequently, the Army Corps of Engineers exercises jurisdiction over all coastal waters up to the mean high water line, including wetlands wholly or partially covered at high tide, in addition to those waters "navigable in fact". Furthermore, Corps regulations themselves provide a higher standard of review when wetlands or marshes are involved[4].

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[1] 430 F2nd 199 (1970)
[2] 39 Fed. Reg. 29552
[3] 33 CFR 209.260 and 209.120
[4] 38 Fed. Reg. 24778 (1973)

Harbor maintenance involves other serious considerations. The National Port System consists of more than 2,000 cargo terminals which are located for the most part in estuaries. The economic role of marine transportation cannot be overestimated and it must be accommodated in any plans for estuarine use. Navigation, construction and harbor maintenance are controlled by the Corps of Engineers but planning and development should be guided by overall regional development plans in order to provide for the most appropriate use and development of estuaries as a whole (84).

The last component of estuarine management is the regulation of fisheries, a field most clearly in the province of State jurisdiction. The most consistent thread running through the history of fisheries regulations in the United States is that, providing there is no conflict with Federal law, the regulation of fishing in territorial waters is within the police power of the individual State (49). The Submerged Lands Act corroborated this trend by encouraging coastal states to take necessary measures for the protection and conservation of natural resources, implying that Congress intended to leave the matter of domestic jurisdiction over marginal sea areas to the individual states, and indicating that it was in the public interest for the states to manage and conserve their own fisheries resources. Furthermore, it has been judicially declared that the States regulate fisheries, provided that Congress has not chosen to do so, and Congress has apparently decided that the uniform regulation of fisheries is not in the best interest of the nation due to the variations in fisheries and the diversity in methods of capture[1]. State laws must therefore meet two tests: one against the supremacy clause in those instances where the State law and the Federal law attempt to regulate the same area, and another against other Federal constitutional commands such as due process and equal protection.

Several interstate commissions have been created for the purpose of regulating fisheries, both with and without the participation of the Federal government. The Atlantic States Marine Fisheries Compact, the Gulf States Marine Fisheries Compact and the Pacific Marine Fisheries Compact are examples of compacts composed of representatives from each member state with the National Marine Fisheries Service acting in an advisory and research capacity as a participant.

The Potomac River Fisheries Commission, on the other hand, is an example of an interstate compact with no Federal participation, being composed solely of representatives from the States of Maryland and Virginia.

In spite of this strong State role, however, the Federal government by virtue of the decision of Justice White in the case of U. S. v. Maine, et al.[2], enjoys exclusive control over living and non-living resources beyond a distance of three nautical miles from the coastline. The advent of increased foreign fishing effort, coupled with the lack of effective international fisheries regulations and the general deterioration of marine and estuarine environments, has had a seriously adverse effect on fisheries stocks.

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[1]See cases in Suher and Hennessee, Part I (49).
[2]35 Original, 17 March 1975, Opinion by Justice White.

Anadromous fishes, which spend a part of their life cycles in the estuarine environment but are subject to capture in areas beyond State jurisdiction, pose special considerations which State management agencies have been unable to incorporate into their overall comprehensive plans for fisheries resource management.

The National Oceanic and Atmospheric Administration is primarily responsible for providing technical and scientific assistance in the area of living resources and environmental protection, and a substantial amount of Federal financial assistance is provided through the Fish and Wildlife Service for acquisition, conservation, restoration and management of fish and game resources.

There are, of course, many other areas in which the Federal institutional framework plays at least an indirect role in estuarine resource management. Federal foreign policy in international fisheries regulations, for example, affects anadromous and catadromous resources which may depend on estuaries, and development of outer continental shelf resources may dramatically affect the health of the estuaries. These factors, however, are too far removed from actual estuarine system management to be considered within the scope of this paper.

It should be quite apparent from the foregoing that it is extremely difficult, if not impossible, to consider within reasonable limits the vast breadth of decisions made with regard to estuarine management. Hopefully, however, the primary contributing factors in the exercise of Federal jurisdiction have been presented here. Major Federal statutes and the areas which they regulate are listed in Table 2.2.

On the State level, it is perhaps unreasonable to expect that agencies will be created within the States' organizational frameworks to function solely or primarily as the manager of the States' estuarine areas, but awareness of the need for closer visible coordination and cooperation between agencies serving planning, management, and advisory roles is increasing (101). The management and planning authorized in the Coastal Zone Management Act and the planning of the Water Resources Council and its river basin commissions may provide the tools, but these programs are presently in the development stage and must be strengthened considerably in order to be truly effective. It is essential that critical decisions impacting estuaries be made not on the basis of specific site-related permit determinations, but rather on the basis of a general comprehensive planning policy which incorporates a consideration of all aspects of the estuarine environment.

Table 2.2. General Listing of Statutes Having an Impact on Estuaries and Their Natural Resources.

Statutes	Preservation, Restoration and Management of Resources: Acquisition	Management of Property	Research
Migratory Water Fowl Refuge Act 16 USC 695	x	x	
Fish and Game Sanctuary Act 16 USC 694B	x	x	
National Wilderness Act 16 USC 1131	x	x	
Wild and Scenic Rivers Act 16 USC 1271	x		
National Conservation Recreational Areas Act 16 USC 460D		X	
National Wildlife Refuge System Act 16 USC 668 DD	x	x	
Land and Water Conservation Fund Act 16 USC 460-4	x		
Endangered Species Conservation Act 16 USC 668 aa	x	x	
Migratory Bird Hunting Stamp Act 16 USC 718	x		
Fish Restoration and Management Projects Act 16 USC 777		x	x
Anadromous Fish Conservation Act 16 USC 757 a	x	x	x
Federal Aid in Wildlife Restoration Act 16 USC 669		x	x
Outer Continental Shelf Lands Act 43 USC 1331		x	
Submerged Lands Act 43 USC 1301		x	
Coastal Zone Management Act 16 USC 1451	x		
Marine Protection, Research and Sanctuaries Act 16 USC Ch 27		x	x
Estuarine Areas Act 16 USC 1221		x	

Pollution Control

Statutes	Dumping	Research	Management	Regulation	Water Quality
Marine Protection, Research and Sanctuaries Act 33 USC 1401	x	x			x
Federal Water Pollution Control Act Amendments 33 USC 1344	x	x	x	x	x
Rivers & Harbors Appropriation Act of 1899 33 USC 401			x	x	x
Oil Pollution Act 33 USC 1001				x	x
Outer Continental Shelf Lands Act 43 USC 1331				x	

Policy

Statutes	Review Power	Goal/National Policy Statement
National Environmental Policy Act 42 USC 4321	x	x
Estuarine Areas Act 16 USC 1221	x	x
Fish and Wildlife Coordination Act 16 USC 661	x	
Department of Transportation Act 49 USC 1655		x

STATE SECTION

The following paragraphs summarize at a State and regional level some of the legal and institutional structures relevant to the estuarine assessment.

Administrative organizations with unique or significant statutory roles as well as specific statutes having major impacts on the estuarine environment are identified. An attempt has been made to limit the discussion of State legislation to those statutes which most directly affect the estuarine environment since an enumeration of all State legislation possibly having an impact on estuarine areas is beyond the scope of this work. For example, most States have enabling legislation for some degree of local zoning and some coastal States have recently enacted legislation pertaining to outer continental shelf development. These statutes, while definitely affecting estuarine resources, do so only indirectly and have, therefore, been omitted.

Significant State and regional problems, as viewed by the States themselves, relative to estuarine resource management are also briefly summarized. Much of the information for this section is from "State Coastal Zone Management Activities, 1974" by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

New England
(Region 01)

The states of the New England Region face pressing energy shortages which have a severe impact on coastal and estuarine management programs. Pressures to locate oil refineries or deepwater ports have so far been resisted in the region. Demands for urban and recreational development in the northeast indicate the need for coordinated action by all of the New England States. Innovative legislation in the region includes Maine's Mandatory Shoreline Zoning and Subdivision Control Law and Massachusetts' Ocean Sanctuaries Act. These States have begun cooperative efforts toward management of estuarine and nearshore resources through a number of regional compacts, the most well known of which is the New England River Basin Commission. Other important compacts include the New England Interstate Water Pollution Control Compact and the Northeastern Water and Related Land Resources Compact.

Maine

Administrative Organizations

- Department of Environmental Protection
- Department of Marine Resources
- Department of Conservation
- Department of Transportation
- Department of Health and Welfare

Major Statutes (Revised Statutes of Maine)

Coastal Conveyance of Petroleum Act (Title 38 § 541 (1973))

Mandatory Shoreline Zoning and Subdivision Control Law (Title 12 § 4811 (1974))

Wetlands Act (Title 12 § 4701 (1974))

Site Location of Development Law (Title 38 § 481 (1974))

Coastal Zone Management Act Responsibility

State Planning Office

Coastal Planning Group

Department of Conservation

Department of Marine Resources

Problem Areas

Lack of an objectively defined and workable resource base.

Lack of administrative control point for the coastal research system as a whole.

New Hampshire

Administrative Organizations

12 state agencies, including Water Supply and Pollution Control Commission.

Major Statutes (New Hampshire Revised Statutes Annotated)

Tidal Waters Act (§ 483-A:1-a (1972))

Coastal Zone Management Act Responsibility

Office of Comprehensive Planning

Problem Areas

Locational siting of a superport, oil refinery, nuclear power plant, and energy production facilities.

Private development on salt marshes and in public waters.

Massachusetts

Administrative Organizations

Office of Environmental Affairs

Department of Natural Resources

Major Statutes (Massachusetts General Laws Annotated)

Coastal Wetlands Protection Act (Ch. 130 § 105 (1974))

Ocean Sanctuaries Act (Ch. 132 A § 13 (1974))

Coastal Zone Management Act Responsibility

Office of Environmental Affairs

Department of Natural Resources

Problem Areas

Need to achieve balance between local, regional, and state decision-making to define explicitly those instances where state intervention in coastal management is necessary.

Siting of power and oil-related facilities, control of air and water pollution, and associated urban blight problems.

Lack of adequate public recreation facilities in the coastal zone.

Connecticut

Administrative Organizations

Department of Environmental Protection
Department of Preservation and Conservation
Division of Environmental Quality

Major Statutes (Connecticut General Statutes Annotated)

Environmental Protection Act (§ 22a-1 (1975))
Pollution Control and Wetlands Programs (Ch. 22)

Coastal Zone Management Act Responsibility

Department of Environmental Protection

Problem Areas

Dense population, urban and industrial development in coastal zone areas.

Threat of growth pressure and poor water quality in critical coastal areas.

Limited public access to the shoreline.

Rhode Island

Administrative Organizations

Coastal Resources Management Council
Department of Administration

Major Statutes (General Laws of Rhode Island Annotated)

Coastal Management Act of 1971 (§ 42-23-1 (1971))
Intertidal Salt Marshes Act (§ 11-46.1-1 (1968))
Coastal Wetlands Act (§ 2-1-13 (1968))

Coastal Zone Management Act Responsibility

Department of Administration
Coastal Resources Management Council
Department of Natural Resources

Problem Areas

Private control of shoreline areas, lack of public access to the shoreline.

Lack of adequate plans for handling dredge materials, toxic wastes, solid wastes, and other potential pollutants.

Inadequate administrative tools for development control.

Middle Atlantic
(Region 02)

The six states of the Middle Atlantic Region face complex and varied problems relating to their estuarine and marine resources. New York and New Jersey are confronted with intense urban pressures for residential, industrial, and recreational shoreline development. States to the south are not as highly urbanized, but must balance the conflicting demands of both urban and rural areas regarding their coastal zone areas. In response, Delaware has enacted an innovative, though restrictive, Coastal Zone Act. Most of the Middle Atlantic States have consolidated their environmental programs into a Department of Environmental Affairs or Department of Natural Resources. Virginia has not, and as a result there are overlapping jurisdictional authorities among the thirty-seven state agencies which affect the coastal zone. Important interstate compacts within the Middle Atlantic Region include the Interstate Commission on the Potomac River Basin, Delaware River Basin Commission, Potomac River Fisheries Commission, and the Susquehanna River Basin Compact.

New York

Administrative Organizations

Department of Environmental Conservation
Office of Planning Services
Environmental Facilities Corporation
Department of Health

Major Statutes (McKinney's Consolidated Laws of New York)

Environmental Conservation Law (N. Y. Env. Conserv. Law § 1-0101 (1973))

Tidal Wetlands Act (N. Y. Env. Conserv. Law § 25-0101 (1974))

Stream Protection Act (N. Y. Env. Conserv. Law § 11-0503 (1973))

Coastal Zone Management Act Responsibility

Department of Environmental Conservation
Office of Planning Services

Problem Areas

Competing land and water uses.
Degradation of state wetlands.
Development of port facilities.
Demand for urban recreational opportunities.

New Jersey

Administrative Organizations
Department of Environmental Protection
Division of Marine Services
Office of Environmental Analysis

Major Statutes (New Jersey Statutes Annotated)
Coastal Wetlands Act (§ 13:9A-1 (1975))
Coastal Area Facility Review Act (§ 13:19-1 (1975))

Coastal Zone Management Act Responsibility
Department of Environmental Protection

Problem Areas
Large-scale uncontrolled residential and commercial waterfront development.
Effects of energy development and waste disposal on coastal resources and ecosystems.
Decline of older, resort-oriented urban areas.

Delaware

Administrative Organizations
Department of Natural Resources and Environmental Control

Major Statutes (Delaware Code Annotated)
Coastal Zone Act (Title 7 § 7001 (1974))

Coastal Zone Management Act Responsibility
State Planning Office
Coastal Zone Management Committee
Department of Natural Resources and Environmental Control

Problem Areas
Demand for expanded deepwater ports.
Intense development of resort-related areas along coast.
Lack of understanding of relationships between development pressures and ecological resources.

Pennsylvania

Administrative Organizations
Department of Environmental Resources
Department of Transportation

Major Statutes (Purdon's Pennsylvania Statutes Annotated)
Statewide Environmental Master Plan (71 P.S. § 510 (1974))
Land and Water Conservation and Reclamation Act (32 P.S. § 5101 (1974))
Clean Streams Law (35 P.S. § 691.4 (1974))
Open Space Preservation Act (16 P.S. § 11941 (1974))

Coastal Zone Management Act Responsibility
Department of Environmental Resources

Problem Areas
Need for consolidated management program.
Resolution of conflicting public and private rights.
Need for balance between urban and ecological demands.

Maryland

Administrative Organizations
Department of Natural Resources
Department of Health and Mental Hygiene

Major Statutes (Annotated Code of Maryland)
Wetlands Act (NR § 9-101 (1974))

Coastal Zone Management Act Responsibility
Department of Natural Resources
Chesapeake Bay and Coastal Zone Advisory Commission

Problem Areas
Loss of wetlands due to development pressures.
Demand for energy-related industry.
Increasing port activity.

Virginia

Administrative Organization
37 separate state agencies, including Virginia Marine Resources Commission, State Water Control Board, Department of Health, and the Virginia Institute of Marine Science.

Major Statutes (Code of Virginia)
Virginia Wetlands Law (§ 62.1-13.1 (1973))
State Water Resources Law (§ 62.1-1.3 (1973))
Critical Environmental Areas Legislation (§ 10-190 (1974))
Open Space Land Act (§ 10-152 (1974))
Erosion and Sediment Control Law (§ 21-89.1 (1974))

Coastal Zone Management Act Responsibility
Coastal Zone Advisory Committee
Division of State Planning and Community Affairs
Virginia Institute of Marine Science

Problem Areas
Coordination of separate state agencies.
Lack of comprehensive coastal zone plan.
Demand for residential and recreational development.
Demand for offshore petroleum development.

South Atlantic
(Region 03)

The states of the South Atlantic Region are largely rural in character and do not face the intense urban pressures of the northeastern states. Florida, however, is an exception. It must deal with the conflicting needs for urban, recreational, and industrial growth. Florida's fragile marine and nearshore environment has been imperiled by man's activities. Other South Atlantic states must also respond to increasing demands for recreational, residential and industrial shoreline development. The problem of shoreline destruction and increasing water pollution are faced by all South Atlantic states. Interstate compacts in the region include the Atlantic States Marine Fisheries Compact and the Coastal Plain Regional Commission. Innovative legislation in the region is typified by Florida's Environmental Land and Water Management Act.

North Carolina

Administrative Organizations
Department of Administration
Department of Natural and Economic Resources
Office of Marine Affairs
Marine Science Council
Division of Health Services

Major Statutes (General Statutes of North Carolina)
Environmental Policy Act (§ 143B-282 (1974))
Coastal Area Management Act of 1974 (§ 113A-100 (1974))
Sedimentation and Pollution Control Act (§ 113A-50 (1974))
Wetlands Protection Act (§ 113-230 (1974))

Coastal Zone Management Act Responsibility
Department of Natural and Economic Resources
Office of Marine Affairs
Department of Administration
Coastal Resources Commission

Problem Areas
Balancing need for economic and transportation development with wildlife and fisheries needs.
Maintaining water quality.
Providing shoreline recreation opportunities.

South Carolina

Administrative Organizations
Wildlife and Marine Resources Department
Department of Health and Environmental Control

Major Statutes (Code of Laws of South Carolina)
Pollution Control Act (§ 63-195 (1974))

Coastal Zone Management Act Responsibility
Coastal Zone Planning and Management Council

Problem Areas
Methods needed to assist industrial development while minimizing environmental impacts.
Conflicts between increasing pressure for coastal area development and need for environmental protection.
Resort and urban growth in areas subject to flooding, hurricanes, unsuitable soils and erosion.

Georgia

Administrative Organizations
Department of Natural Resources
Coastal Zone Management Policy Development Committee

Major Statutes (Georgia Code Annotated)
Coastal Marshlands Protection Act (§ 45-136 (1974))

Coastal Zone Management Act Responsibility
Office of Planning and Budget
State Department of Law
Department of Natural Resources

Problem Areas
Lack of intergovernmental cooperation and coordinated policy in the coastal zone.
Increasing demand for development impacting on fragile coastal zone resources.
Inadequate water treatment facilities and decline of water quality.

Florida

Administrative Organizations
Department of Natural Resources
Coastal Coordinating Council

Major Statutes (Florida Statutes Annotated)
Environmental Land and Water Management Act (§ 380.012 (1974))
Internal Improvement Trust Fund Act (§ 253.67 (1975))
Coastal Zone Management Act (§ 370.0211 (1974))

Coastal Zone Management Act Responsibility
Coastal Coordinating Council (Department of Natural Resources)
Department of Administration

Problem Areas

Lack of jurisdictional distinctions among the various Federal, State, county and municipal agencies with coastal zone management functions.

Destruction of marine environment through beach erosion and dredge and fill projects.

Gulf Coast-Lower Mississippi
(Regions 08, 12)

The states of the Gulf Coast are faced with the prospect of greatly increased activity in the energy field. Increased exploration, industrial development, and refining needs threaten efforts to preserve coastal areas. In addition, increased fishing activity may affect the marine resources of the area. There is also increased pressure for public and recreational access to the limited coastal areas. Finally, much of the area is susceptible to hurricane damage, which can magnify the environmental problems posed by all of the preceding issues.

The Gulf States, however, have acted to ensure better management of coastal areas. Although authority is somewhat fragmented in the several states among a variety of governmental entities, recent action in several states may lead to a more coordinated effort. Mississippi, for example, placed primary responsibility for coastal areas in its Marine Resources Council, made up of the Governor and the heads of several other departments involved in conservation and environmental matters. This approach can cut across jurisdictional lines and focus governmental power on coastal zone problems.

Interstate cooperation ranging from bi-state cooperation to multi-state compacts is also evident in the Gulf Region. Mississippi and Alabama participate in the Mississippi-Alabama Sea Grant Consortium and have joined in planning for an off-shore port facility. Compacts include the Tennessee River Basin Water Pollution Control Compact and the Gulf State Marine Fisheries Compact. Such cooperation among coastal zone states would seem useful in developing a regional approach to problem solving.

Texas

Administrative Organizations

School Land Board
Texas Coastal and Marine Council
Interagency Natural Resources Council
General Land Office

Major Statutes (Vernon's Texas Statutes)

Coastal Public Lands Management Act (Art. 5415e-1 (1974))

Coastal Zone Management Act Responsibility

Texas General Land Office
Texas Coastal and Marine Council
Highway Department
Industrial Commission
Water Quality Board

Problem Areas

Need for coordinated planning to permit growth and economic development without sacrificing recreational and environmental values.

Shortage of freshwater supply in certain areas.

Decision making done on local level, often at expense of state or national interests.

Jurisdiction divided among numerous governmental entities.

Louisiana

Administrative Organizations

State Planning Office
Department of Conservation
State Land Office
Louisiana Coastal Commission
Louisiana Energy Commission
Council on Environmental Quality

Major Statutes (Louisiana Revised Statutes)

Coastal and Marine Resources Conservation and Development Act (§ 51:1361 (1975))

Natural Resources and Energy Act (§ 30:501 (1975))

Coastal Zone Management Act Responsibility

State Planning Office
Wildlife and Fisheries Commission
Louisiana State University Sea Grant Program

Problem Areas

Saltwater intrusion into previously freshwater areas, especially in areas where fresh water is already in short supply.

Pressures for increased energy exploration and development must be balanced against potential environmental damages.

Alabama

Administrative Organizations

Alabama Development Office
Department of Conservation and Natural Resources
Alabama State Docks Authority
Alabama Highway Department

Major Statutes (Code of Alabama)

Coastal Areas Development Act (Title 8 § 312 (1973))

Environmental Improvement Authorities Act (Title 8 § 270 (1973))

Coastal Zone Management Act Responsibility

Alabama Development Office
Alabama Coastal Area Board
Department of Conservation and Natural Resources
South Alabama Regional Planning Commission

Problem Areas

Increased pressures for development of state coastal areas.

Decreasing supply of fresh water.

Plans for increased petroleum production in offshore areas pose new problems for coastal areas.

Mississippi

Administrative Organizations

Marine Resources Council
Marine Conservation Commission
Gulf Coast Research Laboratory
Air and Water Pollution Control Commission

Major Statutes (Mississippi Code Annotated)

Coastal Wetlands Protection Act (§ 49-27-1 (1974))
Air and Water Pollution Control Law (§ 49-17-1 (1974))

Coastal Zone Management Act Responsibility

Marine Resources Council
Mississippi-Alabama Sea Grant Consortium
Southern Mississippi Planning and Development District
Gulf Regional Planning Commission

Problem Areas

Increased competition for use of available coastal areas for a variety of uses.

Problems associated with increased development of the petroleum industry.

Inadequate planning to locate coastal development in areas least prone to hurricane damage.

Pacific
(Regions 17, 18, 19, 20)

The states in the Pacific face a variety of problems in the coastal areas. Rising populations and pressure to develop the coastal areas threaten the preservation of delicate ecological areas. Pressures for commercial, industrial, and residential development threaten public access to coastal areas. Hawaii, California, and Oregon seem particularly affected by these pressures. Increased demands for energy require stepped up exploration and development of energy resources. California, Washington, and Alaska are perhaps most affected by the problems associated with such energy development activity. Alaska is unique among the states due to its great size, small population and the large role the Federal government occupies in state affairs. Within the entire region, however, coordinated Pacific states have also shown they can work together on various interstate matters, as indicated by their cooperation in the Pacific States Marine Fisheries Compact, the Columbia River Fisheries Compact, and the Pacific Northwest River Basin Compact. Further coordinated action on an interstate basis may be developed in planning future coastal zone development and conservation.

California

Administrative Organizations

California Coastal Zone Commission
State Lands Commission
Department of Conservation
Office of Planning and Research
Department of Parks and Recreation

Major Statutes (California Annotated Public Resources Code)

Coastal Zone Conservation Act (§ 27304 (1975))
Environmental Quality Act (§ 21000 (1975))
Outdoor Recreation Resources Planning Act (§ 5099 (1972))

Coastal Zone Management Act Responsibility

California Coastal Zone Commission
Department of Navigation and Ocean Development
San Francisco Conservation and Development Commission
Delta Advisory Planning Council

Problem Areas

Fragmentation of authority with a resultant lack of coordination among various governmental entities with coastal jurisdiction.
Preserving the ecological balance in the face of pressures for increased residential and energy development.

Oregon

Administrative Organizations

Oregon Land Conservation and Development Commission
State Highway Commission
Division of State Lands
Department of Environmental Quality

Major Statutes (Oregon Revised Statutes)

Coastal Conservation and Development Act (§ 191.150 (1974))
Ocean Shores Act (§ 390.605 (1974))

Coastal Zone Management Act Responsibility

Oregon Land Conservation and Development Commission

Problem Areas

Fragmentation of decision-making among special purpose units of government.
Conflicting pressures of economic development and environmental protection and conservation.
Need for baseline data for development of management standards.

Washington

Administrative Organizations

Department of Ecology
Department of Natural Resources
State Planning and Community Affairs Agency
State Parks and Recreation Commission

Major Statutes (Revised Code of Washington Annotated)

Shoreline Management Act (§ 90.58.010 (1974))
State Environmental Policy Act (§ 43.21C (1974))
Natural Area Preserves Act (§ 79.70.010 (1974))
Marine Recreation Land Act (§ 43.99 (1974))

Coastal Zone Management Act Responsibility

Department of Ecology
Department of Natural Resources
University of Washington Sea Grant Program
Puget Sound Governmental Conference

Problem Areas

Increased pressure to develop valuable shorelands of the state.
Need for increased coordination among the state and local agencies involved in coastal planning.
Increasing the limited public access to the coastal area and increasing recreational facilities.

Alaska

Administrative Organizations

Department of Environmental Conservation
Department of Natural Resources
State Water Resources Board
Environmental Advisory Board

Major Statutes (Alaska Statutes)

Alaska Water Use Act (§ 46.15.010 (1971))
Environmental Conservation Act (§ 46.03.010 (1971))

Coastal Zone Management Act Responsibility

Department of Environmental Conservation

Problem Areas

Domestic and foreign effort leading to excessive exploitation of fishing resources.
Environmental threats from increased oil exploration and production.
Conflicting use demands for shoreline and other competing interest groups.
Unpopularity of management planning which seems to impede economic development as demands for development of energy and natural resources increase.

Hawaii

Administrative Organizations

State Department of Planning and Economic Development
State Land Use Commission
Department of Land and Natural Resources
Office of Environmental Quality Control
Natural Area Reserves System Commission

Major Statutes (Hawaii Revised Statutes)

Coastal Zone Management Act (§ 205A-1 (1974))
Hawaii Land Use Law (§ 205-2 (1974))
Natural Area Reserves System Act (§ 195-1 (1974))

Coastal Zone Management Act Responsibilities

Department of Planning and Economic Development
Department of Land and Natural Resources
University of Hawaii

Problem Areas

Coordination of coastal zone planning with other land use planning to develop a coordinated framework.
Definition of coastal zone boundaries in Hawaii's unique geographical situation.
Need to deal with problems on resort and residential shoreline uses, coupled with lack of public access to the state's shorelines.

Great Lakes
(Region 04)

The Great Lakes States face problems in several areas. High lake levels have greatly increased damage from flooding and shoreline erosion. Increasing populations have led to increased demands for public access to shorelands. At the same time there has been a corresponding increase in pressures to develop coastal areas for residential use. Water quality is also recognized as a major problem.

The problem of fragmented responsibility for the management of the coastal areas is evident in the States of this region. Some States have acted to remedy the situation, either by directing local entities to take action, as in Wisconsin, or by placing primary responsibility for management and coordination with a single state agency, as Michigan has done. The problem, however, has not been remedied everywhere. For example, Indiana has only recently expressed an interest in participating in the program of the Coastal Zone Management Act of 1972, and as of yet has no firm plan for management of its coastal resources.

The Great Lakes States have shown an ability to coordinate their activity on a bi-state or multi-state level, as evidenced by the existence of several compacts. Among those are the Wabash Valley Compact, the Lake Superior Basin Water Quality Management Plan, and the well known Great Lakes Basin Compact, in which all the Great Lakes States participate. The planning and coordinating functions of the Great Lakes Compact could be effectively utilized in improving the coastal zone management system.

Minnesota

Administrative Organizations

Department of Natural Resources
Minnesota Resources Commission
State Planning Agency
Department of Economic Development
Department of Highways
State Environmental Quality Council

Major Statutes (Minnesota Statutes Annotated)

Shorelands Protect Act (§ 105.485 (1974))
Minnesota Critical Areas Act (§ 116G.01 (1974))
Regional Development Act (§ 462.381 (1974))
Natural Resources and Recreation Act (§ 86.01 (1964))

Coastal Zone Management Act Responsibility

Department of Natural Resources
Department of Economic Development
Arrowhead Regional Development Commission

Problem Areas

Lack of land use controls, resulting in strip development in many shoreland areas.
Need for greater public land holding to insure increased public access to shoreline areas.
Need to protect against increased erosion.

Wisconsin

Administrative Organizations

Department of Administration, State Planning Office
Department of Natural Resources
State Coastal Zone Coordinating and Advisory Council

Major Statutes (Wisconsin Statutes Annotated)

Navigable Waters Protection Act (§ 144.26 (1974))
State Conservation Act (§ 23.09 (1974))
State Water Resources Act (§ 144.025 (1974))
Shorelands Zoning Act (§ 59.971 (1974))

Coastal Zone Management Act Responsibility

Department of Administration
State Coastal Zone Coordinating and Advisory Council
Department of Natural Resources
University of Wisconsin
Various regional planning and development commissions

Problem Areas

Erosion of shoreline areas.
Inadequate public access to the Great Lakes.
Increased demand for economic development which threatens ecologically sensitive areas.

Illinois

Administrative Organizations

Department of Conservation
Department of Transportation
Environmental Protection Agency
Pollution Control Board
Illinois Institute for Environmental Quality

Major Statutes (Illinois Annotated Statutes)

Environmental Protection Act (Ch. 111½ § 1001 (1974))

Coastal Zone Management Act Responsibility

Department of Conservation
Department of Transportation
State Coastal Zone Advisory Council
Shoreline Advisory Committee
Northeast Illinois Planning Commission

Problem Areas

Need to inject consideration of state and national needs into decisions which are now made largely on the local level.
Need to establish priorities in the increasing competition for available coastal land.
Problem of defining a coastal zone boundary in a heavily urbanized setting.

Indiana

Administrative Organizations

Department of Natural Resources
Recreational Development Commission
Indiana Environmental Management Board
State Environmental Quality Board

Major Statutes

No coastal zone management act.

Coastal Zone Management Act Responsibility

State Planning Services Agency (preliminary)

Problem Areas

No coastal zone management act.
Need for more public access to the state's limited coastal areas.

Michigan

Administrative Organizations

Department of Natural Resources
Natural Resources Commission

Major Statutes (Michigan Compiled Laws Annotated)
Shorelands Protection and Management Act (§ 281.631 (1975))
Wilderness and Natural Areas Act (§ 322.751 (1975))
Farmland and Open Space Preservation Act (§ 554.701 (1975))
Flood, Drainage, and Beach Erosion Control Act (§ 281.601 (1967))

Coastal Zone Management Act Responsibility
Department of Natural Resources
10 Regional planning agencies

Problem Areas
Only minimal local planning programs for much of the shoreland area, which is subject to increasing recreational and residential demands.
Need for rehabilitation of blighted urban waterfront areas.
Need to deal effectively with serious damage resulting from flooding and erosion.

Ohio

Administrative Organizations
Department of Natural Resources
Environmental Protection Agency
Ohio Water Commission

Major Statutes (Ohio Revised Code Annotated)
Nature Preserves Act (§ 1517.01 (1973))
Wild Rivers Areas Act (§ 1501.16 (1973))

Coastal Zone Management Act Responsibility
Department of Natural Resources
Northeast Ohio Areawide Coordinating Agency
Toledo Metropolitan Area Council of Governments
Eastgate Development and Transportation Agency

Problem Areas
Deterioration of resources.
Increased flooding and shore erosion.
Intense development along shoreline.
Jurisdictional conflict and duplication of efforts by various agencies involved with coastal management.

Caribbean
(Region 21)

Because of their unique status as Commonwealth and Territory, Puerto Rico and the Virgin Islands face unusual problems relating to management of their marine and nearshore environments and have had to develop innovative programs to confront these issues. Major problems in the region include the degradation of the shore environment on which these islands' economies depend. Increasing pollution is the result of developmental pressures in both Puerto Rico and the Virgin Islands. Both jurisdictions seek to increase public access to their shoreline, now largely dominated by private ownership.

Puerto Rico

Administrative Organizations

Department of Natural Resources
Puerto Rico Planning Board
Environmental Quality Board

Coastal Zone Management Act Responsibility

Department of Natural Resources
Puerto Rico Planning Board
Environmental Quality Board

Problem Areas

Controlling extraction of beach sand for construction purposes.

Controlling coastal land uses, including industrial and harbor development, power plant construction and operation, tourism industries, residential development and waste treatment facilities.

Virgin Islands

Administrative Organizations

Virgin Islands Planning Office
Department of Conservation and Cultural Affairs

Major Statutes (Virgin Islands Code Annotated)

Environmental Protection Act (Title 12 § 531 (1974))
Open Shorelines Act (Title 12 § 401 (1974))

Coastal Zone Management Act Responsibility

Virgin Islands Planning Office

Problem Areas

Private ownership of shoreline areas suitable for recreation.

Legal issues affecting title to submerged lands, and overlapping jurisdiction of territorial agencies, the Federal Government and Denmark.

CHAPTER 3
ESTUARINE RESOURCE HARVEST AND PROJECTIONS

Waldon Kerns and Ivar Strand

This portion of the Assessment of Estuarine and Nearshore Marine Resources report provides: 1) an analysis of recent resource harvest; 2) a discussion of threats to resource bases from harvest competition; and 3) a discussion of future harvest projections.

RECENT RESOURCE HARVEST STATISTICS

Recent harvest statistics for estuarine related resources are presented in this part of the report. Statistics on commercial harvest of fish and shellfish and the related fisheries industry are discussed first. A discussion of sportfishing and waterfowl harvest follows the commercial harvest discussion. A description of other wildlife harvest, bird watching and photography, and recreational boating completes the harvest statistics section.

Commercial Fisheries

The ex-vessel value of estuarine dependent (Appendix 1) commercial fish and shellfish in the U. S. was $490 million in 1972. This value represents approximately 70 percent of the total $704 million U. S. commercial fish catch (72). Tihansky and Meade (104) indicate that 65-90 percent of landings, depending on the region, is comprised of estuarine dependent species. As shown in Table 3.1, the Lower Mississippi Region had the largest catch in weight with over a billion pounds caught. The Middle Atlantic Region was a close second with over 856 million pounds caught. While the Texas-Gulf Region had a catch of only 109 million pounds, their ex-vessel value of approximately $84 million was the highest regional ex-vessel value of catch. The lowest ex-vessel value of catch was approximately $133,000 for the Hawaii Region.

Table 3.1. Estuarine Dependent Commercial Fish Harvest by Water Resource Regions, 1972[1].

Region	Weight (lbs)	Ex-Vessel Value (1972 dollars)
New England	196,533,952	54,388,351
Middle Atlantic	856,156,152	66,836,138
South Atlantic	229,010,976	35,266,371
East Gulf	99,185,168	53,433,712
Lower Mississippi	1,039,749,120	69,742,976
Texas-Gulf	109,538,224	83,681,472
California-South Pacific	48,756,780	9,113,316
Columbia-North Pacific	108,327,952	35,996,994
Alaska	369,473,168	74,119,052
Great Lakes	59,501,060	7,193,780
Hawaii	86,594	133,688
Total	3,107,319,146	489,905,870

Source: Unpublished 1972 statistics from National Marine Fishery Service, NOAA.
[1]Appendix 1 contains list of estuarine dependent species.

Commercial Fishing by Region

According to the 1970 Estuarine Study:

> "The most important estuary dependent or associated fish are: shrimp, salmon, lobster, flounder, blue, stone and rock crab, clams, oysters, and menhaden. The shrimp fishery is of great importance to coastal economics of the South Atlantic and Gulf of Mexico Regions. Oysters are particularly important to the Chesapeake economy. Clams support a significant sector of the coastal economics in the Middle Atlantic and Chesapeake Bay Regions. The salmon fishery is of critical importance to the economy of Alaska, and lobster fishing contributes significantly to the New England economy, especially in Maine and Rhode Island. Harvesting of menhaden, the major U.S. landed fish used for animal feed and for industrial purposes, has made important contributions to the Chesapeake Bay and South Atlantic Regions and is becoming increasingly important to the Gulf States" (84, p. 17).

These statements are substantiated in Table 3.2 which indicates the most important estuarine dependent species, in terms of weight and dollar value, for Water Resource Regions. An inspection of that table reveals that sea herring accounts for 44 percent of the New England poundage but only 4.2 percent of the dollar volume. Northern lobster accounts for only 14.7 percent of the poundage but 64.2 percent of the dollar volume. Menhaden makes up 66.8 percent of the weight volume in the Atlantic whereas oysters account for the largest dollar percentage with 28.5 percent. Menhaden also accounts for the largest landings in the South Atlantic, East-Gulf and Lower Mississippi regions with 46.3 percent, 66.3 percent and 89.3 percent, respectively. In each of these three regions shrimp returns the largest dollar value at 52.1 percent, 69.1 percent and 67.5 percent, respectively. Shrimp also accounts for 89 percent of the landings and 95.7 percent of the dollar volume in the Texas-Gulf Region.

In the Columbia-North Pacific Region, four salmon species account for 42.2 percent of the quantity and 67.4 percent of the dollar volume. In California, squid makes up 41.3 percent of landings, but several species account for higher dollar value. Salmon, crab, and shrimp are the major weight and dollar volume species in Alaska. In Hawaii, spiny lobsters account for 83.9 percent of the weight volume as well as 77.6 percent of the dollar volume.

Another interesting characterization of regional fisheries is the motivation of the fishermen (9). The first group, representing the majority of fishermen, has non-monetary rewards such as independence and pleasure of the sea as one of their primary objectives. They use relatively unsophisticated production technology and usually own and operate their own boats. Participation in the fisheries is frequently

Table 3.2. Most Important Species of Estuarine Dependent Commercial Fish Harvest by Water Resource Regions, 1972.

Region	Most Important Species	Landings Pounds (1,000)	% Total Region Landings	Landings Dollars (1,000)	% Total Region Dollars
New England	Sea Herring	87,612	44.0	2,286	4.2
	Menhaden	30,692	15.6	416	0.8
	Northern Lobster	28,886	14.7	34,394	64.2
	Unclassified Shrimp	24,460	12.2	4,587	8.4
Middle Atlantic	Menhaden	572,146	66.8	11,638	17.4
	Hard Crabs	78,484	9.2	9,459	12.7
	Northern Lobster	3,380	0.4	4,744	7.1
	Hard Clams	12,322	1.4	16,108	21.1
	Oysters	26,469	3.0	19,051	28.5
South Atlantic	Herring	21,424	9.4	366	1.0
	Menhaden	105,951	46.3	1,502	4.2
	Hard Crabs	36,248	15.8	3,631	10.0
	Spiny Lobster	6,433	2.8	6,413	18.0
	Unclassified Shrimp	25,248	11.0	18,469	52.1
East Gulf	Menhaden	178,917	66.3	2,935	5.5
	Spiny Lobster	5,379	2.0	5,746	10.8
	Unclassified Shrimp	48,327	17.9	36,935	69.1
Lower Mississippi	Menhaden	928,251	89.3	15,279	21.9
	Unclassified Shrimp	83,031	8.0	47,063	67.5
Texas-Gulf	Hard Crabs	6,464	5.9	653	0.8
	Unclassified Shrimp	97,577	89.0	80,098	95.7
California-South Pacific	King Salmon	4,251	8.7	3,330	36.5
	Coho Salmon	2,172	4.5	1,499	16.4
	Rockfishes	16,334	34.5	1,484	16.3
	Oysters	885	1.8	762	8.7
	Squid	20,159	41.3	534	5.9
Columbia-North Pacific	Unclassified Cod	10,423	9.6	778	2.2
	Rockfishes	16,351	15.1	1,110	3.1
	King Salmon	12,639	11.7	7,433	20.8
	Chum Salmon	9,530	8.8	3,884	10.8
	Red Salmon	7,172	6.6	3,645	10.1
	Silver Salmon	16,346	15.1	9,232	25.7
	Ocean Shrimp	22,313	20.6	3,140	8.7
	Pacific Oyster	7,486	6.9	5,422	15.1
Alaska	Red Salmon	41,942	11.4	10,732	14.5
	Coho Salmon	13,007	3.5	5,738	7.7
	Chum Salmon	64,778	17.5	11,827	16.0
	King Crab	94,244	25.5	31,840	43.0
	Tanner Crab	46,010	12.5	5,637	7.6
	Shrimp	83,826	22.7	4,217	5.7
Great Lakes	Alewives	29,654	46.6	305	4.6
	Carp	7,287	11.4	341	5.1
	Chubs	7,523	11.8	1,481	22.3
	White Fish	3,955	6.2	1,865	28.0
	Yellow Perch	4,024	6.3	1,221	18.0
Hawaii	Hard Crabs	5	5.7	8	5.1
	Spiny Lobster	73	83.9	104	77.6
	Squid	3	3.5	17	12.7

Source: Unpublished 1972 statistics from National Marine Fishery Service, NOAA, California data for 1971. Alaska data (1973) from Alaska Catch and Production Commercial Fisheries Statistics, Statistical Leaflet No. 26, 1973.

seasonal and will vary from year to year. This group includes inshore lobster fishermen in New England and Pacific salmon and tuna fishermen. Salmon gill netting in the Columbia-North Pacific and Alaska regions is an example of a highly seasonal, low investment enterprise. The Atlantic coast and Gulf of Mexico support a sizable hook and line and net fishery. Many watermen in the Chesapeake Bay belong to this category.

The second group of fishermen is those for whom the monetary rewards are of primary importance, but non-monetary rewards are also a part of the objective function. Production technology tends to be more complex but less skill is required. Investment is higher and there may be one to six employees. Boats are generally utilized in more than one fishery. The Gulf of Mexico shrimp fishermen exemplify this group. The offshore lobster fishermen of New England with the ability to fish flounder and cod are included in this group. Others include North Atlantic scallop fishermen; the North Atlantic drag boat skipper; West Coast shrimp, sole, rockfish and cod fishermen; North Pacific halibut; Washington and Alaska salmon purse seine fishermen; and the Pacific Northwest combination boat skipper.

The third group has an objective function in which monetary rewards clearly dominate. These fishermen are least in number but greatest in economic importance. Production technology is very complex and frequently requires employment of technical specialists. Investments of over $1 million are common with a few fishing companies owning and operating several $1 million boats. As many as 15 employees may be on board a vessel. The king crab fishermen of Western Alaska demonstrate this group as do some Western Alaska shrimp fishermen, Gulf of Mexico shrimp fishermen, and North Atlantic drag boat skippers.

The Processing and Wholesaling Sectors

The ex-vessel values underestimate the total importance of commercial fishing to the regional economies. Additional economic activity is generated by the processing, transportation, and marketing segments of the commercial fisheries. In 1972, for example, the estuarine regions had a total of 1,725 fishery processing plants and 1,759 wholesale plants (Table 3.3). Of the processing plants, 345 are located in the Middle Atlantic Region. In addition to the 86,699 full-time and 68,129 part-time commercial fishermen in the U. S., average yearly employment was approximately 56 thousand in processing and over 8 thousand in wholesaling (72). The largest employment of fishermen, processors, and wholesalers was in the New England and Middle Atlantic regions.

Table 3.3. Commercial Fishery Retail and Wholesale Activity by Water Resource Regions, 1972[1].

Region	Number Plants Processing	Number Plants Wholesale	Avg. Yearly Emp. Processing	Avg. Yearly Emp. Wholesale	Commercial Fisheries Fulltime	Commercial Fisheries Total
New England	231	269	7,543	1,266	11,940	26,749
Middle Atlantic	345	411	9,822	2,204	13,938	28,943
South Atlantic	162	283	4,771	867	8,896	12,325
East Gulf	211	196	5,654	722	9,035	11,257
Lower Mississippi	124	105	3,262	410	9,200	12,550
Texas-Gulf	82	78	2,561	708	6,610	13,895
California-South Pacific	94	80	6,854	720	6,048	11,200
Columbia-North Pacific	130	28	3,770	266	3,720	13,705
Alaska	223	206[2]	3,500	ND	14,720	18,400
Great Lakes	92	87	1,658	862	743	3,017
Hawaii[3]	26	16	3,033	193	1,363	1,693
Caribbean	5	ND	4,084	ND	486	1,094
Total	1,725	1,759	56,512	8,218	86,699	154,828

Source: Current Fishery Statistics No. 6400, Fisheries of the U.S., 1973. National Marine Fisheries Service, NOAA, March 1974, pp. 86-88. Caribbean data was for Puerto Rico and obtained from Fishery Statistics of U.S., 1971, Statistical Digest No. 65, NOAA, October, 1974, p. 379.

[1]Statistics are state totals for those states that are contiguous to marine waters.

[2]Personal letter from Howard Ness, National Marine Fisheries Service, Juneau, Alaska.

[3]Includes Hawaii and American Samoa.

ND, No data available.

Processors can be differentiated in terms of scale and vertical integration (9). Dealers as opposed to processors handle a majority of the South Atlantic finfishes, northern lobster, troll-caught salmon, some blue and dungeness crabs, and clams. The dealer may hold fish on ice or in cold storage for only a day or two, then ship to the wholesale or retail market. Sales volumes for processors range from $50,000 to $100 million. Only 36 percent of the 200 west coast processors and dealers had sales in excess of $500,000. Processors at the top in sales generally are highly integrated manufacturing and marketing organizations dealing in nearly every seafood product. Most other seafood processors and dealers tend to specialize in two, three, or four seafoods and obtain supplies on a regional rather than a national basis. Most of the approximately 80 fishery cooperatives in the U.S. simply act as agents for their members.

Technological advances in the fishing industry during the next decade will primarily affect the fishing fleet rather than fixed estuary facilities. "The trend in fishing is toward larger operating units. Vessels are becoming larger as more effective gear and storage facilities permit greater fishing ranges and increased catches at sea. The presence of Russian and Japanese fleets with large stern trawlers and factory ships capable of processing entire catches at sea clearly indicates the trend" (84, p.18).

Sport Fishing

Confusion exists over the evaluation of sport fisheries because of the inability to define and accurately measure the product. One reason is that estuarine and other areas of sportfishing activities provide a fishing experience rather than just the fish as a commodity. An example of this inaccuracy of sportfishing evaluation is exemplified by the following quote from a study of recreational fishing by the National Marine Fisheries Service:

> "The 1970 Salt-Water Angling Survey (Current Fishery Statistics No. 6200, National Marine Fisheries Service, 1973) estimated that 3,433,000 salt-water anglers fished from Maine to Cape Hatteras, North Carolina in 1970. The present survey covered essentially the same area (Maine through Virginia) and estimated 10,856,000 anglers fished during 1973-1974" (75, p.7).

The difference in the number of anglers estimated by the two surveys results from the following: age of persons included, minimum time spent fishing, inclusion or exclusion of shellfish, and the passage of time between surveys.

Despite these measurement difficulties, people familiar with the subject believe that sportfishing and other recreational values are substantial with a dollar impact at least equal to that of the commercial industry (94, pp. 14-15). For example, a 1970 study by the National Marine Fisheries Service (70) shows a national total of more than 9 million saltwater anglers with a catch of 1.6 billion pounds (Table 3.4). Saltwater anglers would have to spend only $67 per day on sportfishing to equal the ex-vessel value of 1970 U.S. landings. It is important to note that saltwater anglers fish both in estuaries (tidal rivers, bays, lagoons, sounds) and oceans, with 57 percent of fish landings taken in estuaries (95, p.2).

Table 3.4. Estimated Number of Salt-Water Anglers and Their Catches by Region, 1970.

Region [1]	Number Anglers (1,000)	Fish Catch: Number (1,000)	Fish Catch: Weight (lbs) (1,000)
North Atlantic - New England and New York	1,666	117,014	267,451
Middle Atlantic - New Jersey to Cape Hatteras	1,767	168,209	246,267
South Atlantic - Cape Hatteras to Florida Keys	1,808	184,177	403,913
East Gulf of Mexico - Florida West Coast to Mississippi River	1,478	188,888	334,120
West Gulf of Mexico - Mississippi River to Texas	872	97,708	151,608
South Pacific - Pt. Conception South	894	37,221	94,234
North Pacific - Pt. Conception North	1,311	24,100	79,230
All Regions	9,392	817,317	1,567,823

Source: 1970 Salt-Water Angling Survey, Current Fishery Statistics No. 6200, National Marine Fishery Service, NOAA, April, 1973, p. 29.

[1]Survey regions used in Source.

Table 3.4 shows that the South Atlantic Region, which includes the area from Cape Hatteras to the Florida Keys, had the largest number of anglers as well as the largest catch of approximately 404 million pounds. The smallest number of anglers appeared in the West Gulf of Mexico Region which includes the area from the Mississippi River through Texas. However, this region had a larger catch in pounds than the South and North Pacific regions.

Another source, the National Survey of Hunting and Fishing (85), provides a breakdown of saltwater fishing by the three coastal areas. The Atlantic coast with over 5 million fishermen in 1970 had over 50 percent of the national total as well as over 50 percent of the recreational days (Table 3.5). However, the Gulf coast sport fishermen spent an average of $178 on fishing activity as compared to only $128 for the Atlantic coast and $84 for the Pacific coast. The average expenditure for all fishermen was $129 per person and $11 per recreation day. Thus sportfishing expenditures in 1970 exceeded the ex-vessel value of seafood landings.

A separate study of Southeastern saltwater fishing (21) indicates that the average value per day as determined by participants for saltwater fishing is $59.80 per day as compared to $40.84 for freshwater fishing.

Table 3.5. Time and Money Spent on Salt-Water Sport Fishing in Coastal Areas, 1970.

Area	Number Fished in Salt-Water (12 and Over) (1,000)	Amount Spent Total (1,000)	Per Person ($)	Number Recreation Days (1,000)
Atlantic Coast	5,010	636,380	127	61,032
Gulf Coast	2,272	404,646	178	35,624
Pacific Coast	2,178	183,679	84	17,037
Total	9,460	1,224,705	129	113,694

Source: National Survey of Fishing and Hunting, 1970. Fish and Wildlife Service, U.S. Department of the Interior, Resource Publication 95.

Waterfowl

Waterfowl harvest is the primary hunting activity associated with the estuaries. Annual harvest of waterfowl by Water Resource Regions was calculated from unpublished survey data obtained from the Office of Migratory Bird Management of the U.S. Fish and Wildlife Service (81). Ducks and geese are the primary species studied, with ducks being categorized as either divers or dabblers (Appendix 2).

A total of more than 583 thousand divers, about 2.3 million dabblers, and approximately 375 thousand geese were harvested annually between 1961 and 1970 in those counties included in the Water Resource Regions associated with estuarine areas (Table 3.6). These harvests represent 44 percent of the total U.S. harvest of divers, 27 percent of the dabblers, and 33 percent of the geese.

Table 3.6. Distribution of Average Annual Harvest of Diving and Dabbling Ducks and Geese by Water Resource Regions[1].

Region	Total Divers[2]	Total Dabblers[2]	Total Geese[2]
New England	45,273	99,302	5,236
Middle Atlantic	111,983	247,923	135,852
South Atlantic	49,062	114,851	12,648
East Gulf	30,784	42,947	902
Lower Mississippi	78,016	530,449	64,968
Texas Gulf	34,381	275,196	90,383
California-South Pacific	49,991	302,152	14,369
Columbia-North Pacific	69,175	458,270	21,477
Alaska	7,396	50,268	12,254
Great Lakes	107,062	156,300	16,650
Total (Regions)	583,123	2,277,658	374,739
Total (U.S.)	1,314,470	8,297,716	1,122,441

Source: Unpublished data, obtained from Chief, Waterfowl Harvest Surveys, Office of Migratory Bird Management, U.S. Fish and Wildlife Service, Laurel, Maryland.
[1]Harvest data for diving and dabbling ducks are for 1960-1970. Harvest in Alaska is for period 1966-1970. Harvest data for Geese are for 1962-1970.
[2]See Appendix 2 for list of species.

The estuarine related diver harvest was greatest in the Middle Atlantic and Great Lakes regions. The dabbler harvest was largest in the Lower Mississippi and Columbia-North Pacific regions. The estuarine related geese harvest was largest in the Middle Atlantic Region.

The National Survey of Fishing and Hunting categorizes waterfowl hunters by geographic division and by flyway (85). There were approximately 2.9 million waterfowl hunters in 1970 (Table 3.7). The number of hunters was over 400 thousand in each of three regions, East North Central, West South Central and Pacific. The largest percent of the population participating in hunting activities occurred in the West South Central region. The total U.S. expenditure on waterfowl hunting was in excess of $244 million dollars or $84 per hunter (Table 3.8). The expenditures amounted to $9.73 per participant day. Per person expenditure in the Atlantic Flyway was $145 compared to only $58 in the Central Flyway.

Table 3.7. Number of Waterfowl Hunters by Census Geographic Division, 1970.

Division[1]	Number of Hunters (1,000)	Percent Population
New England	81	.9
Middle Atlantic	192	.7
East North Central	482	1.5
South Atlantic	313	1.3
East South Central	149	1.5
West South Central	492	3.4
Pacific	425	2.1
Total	2,894	1.9

Source: National Survey of Fishing and Hunting, 1970, Resource Publ. 95, U.S. Fish and Wildlife Service, p. 59.

[1]Divisions:
New England: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.
Middle Atlantic: New York, New Jersey, Pennsylvania.
East North Central: Ohio, Indiana, Illinois, Michigan, Wisconsin.
South Atlantic: Delaware, District of Columbia, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.
West South Central: Arkansas, Louisiana, Oklahoma, Texas.
Pacific: Washington, Oregon, California, Alaska, Hawaii.

Table 3.8. Waterfowl Hunting by Flyways, 1970.

Flyway	Persons (1,000)	Expenditures: Total $ (1,000)	Expenditures: $ per Person	Days (1,000)
Atlantic	586	85,331	145	4,303
Mississippi	1,136	66,772	59	10,144
Central	616	35,670	58	4,814
Pacific	556	56,678	102	5,852
Total	2,894	244,451	84	25,113

Source: National Survey of Fishing and Hunting, 1970, Resource Publ. 95, U.S. Fish and Wildlife Service, p. 35.

Other Wildlife Harvest

While waterfowl harvest is the primary hunting activity associated with estuarine areas, limited information exists on other types of wildlife harvest. It is estimated that the fur-trapping business in coastal Louisiana accounts for 30 percent of the total national fur production. Principal harvested species in 1970 include 1.2 million muskrat pelts at a value of $1.5 million, 46 thousand mink pelts worth $231 thousand, 1 million nutria pelts worth $3.8 million, and 104 thousand raccoon pelts worth $233 thousand (30).

Non-Consumptive Activities

Bird Watching and Photography

The 1970 survey of outdoor recreation (76) estimates the number of bird watchers and wildlife photographers for each census division area. Those areas associated with the estuarine zone had a total of 6.8 million birdwatchers in 1970 (Table 3.9). Approximately 4.4 percent of the population in these areas were bird watchers with a total of 411 million recreation days devoted to the activity. These areas had a total of 4.5 million wildlife or bird photographers in 1970 who used 37.8 million recreation days for this activity (Table 3.10).

Table 3.9. Bird Watchers (Persons 9 and Over) by Census Division, 1970[1].

Division[2]	Number of Participants (1,000)	Percent of Population	Recreation Days (1,000)	Days per Participant
New England	584	6.3	51,250	87.8
Middle Atlantic	1,313	4.4	78,963	60.1
East North Central	1,829	5.4	105,899	57.9
South Atlantic	953	3.7	56,010	58.8
East South Central	399	3.1	11,802	34.8
West South Central	576	3.6	25,097	43.6
Pacific	1,114	5.1	58,828	52.8
Total	6,813		411,371	

Source: The 1970 Survey of Outdoor Recreation Activities, Preliminary Report, U.S. Department of Interior (February 1972).
[1]Includes totals for each area not limited to estuarine areas.
[2]For census geographic divisions, see footnote 1, Table 3.7.

Table 3.10. Wildlife and Bird Photography by Census Division, 1970[1].

Division[2]	Number of Participants (1,000)	Percent of Population	Recreation Days (1,000)	Days per Participant
New England	295	3.2	3,313	11.2
Middle Atlantic	917	3.0	8,969	9.8
East North Central	968	2.8	6,983	7.2
South Atlantic	515	2.0	4,197	8.1
East South Central	161	1.5	1,289	8.0
West South Central	513	3.2	2,781	5.4
Pacific	918	4.2	8,382	9.1
Total	4,519		37,828	

Source: The 1970 Survey of Outdoor Recreation Activities, Preliminary Report, U.S. Department of Interior (February 1972).
[1]Includes totals for each area not limited to estuarine areas.
[2]For census geographic divisions, see footnote 1, Table 3.7.

In the Southeast, bird watching households valued their activity at an average of $65.40 per day for a total value of $7.4 billion per year (21). This same Southeastern area study indicates that total wildlife enjoyment including birds, animals, and fish for that region in 1970 was 174 million recreation days with a total value of $12 billion. Animal related recreation activities amounted to a total of 54 million recreation days valued at $6.4 billion. The average value per recreation day was estimated to be $80.30. Fish related recreation was 6 million days for a total value of $391 million. Average daily enjoyment was worth $65.99.

Recreational Boating

While a description and analysis of recreational boating (other than recreational fishing, water skiing, and swimming activities) is not one of our primary topics, a short discussion of these activities is needed if a meaningful discussion of use conflicts is to be accomplished. The dollar value of recreational boating is very difficult to calculate. However, proxy variables such as boat ownership and boat parking and mooring spaces provide a minimum value for these activities.

According to information by Ridgely (34), of the approximately 8 million privately owned recreational fishing boats in the U.S. as of October 1973, about 1 million were used in saltwater recreational fishing. Another study indicates there were a total of 6.7 million recreational boats owned by residents of the estuarine areas (Table 3.11). Over 2.2 million of these were located in the Great Lakes Region and approximately 1.4 million in the Middle Atlantic Region. However, a larger percentage of the regional population were operators of recreational boats in the New England, Lower Mississippi, and Columbia-North Pacific regions.

Table 3.11. Number and Use of Recreational Boating by Water Resource Regions, 1973[1].

Region	Recreational Boats Owned (Residency) (1,000)	Boats per 1,000 Residents	Operators of Recreational Boats	% Regional Population
New England	501	54.9	1,271,956	11.5
Middle Atlantic	1,356	37.6	2,991,265	8.1
South Atlantic	279	42.7	1,248,058	7.8
East Gulf	591	55.4	784,393	7.7
Lower Mississippi	386	102.5	581,779	15.5
Texas Gulf	368	31.2	622,260	5.3
California-South Pacific	583	62.9	1,364,838	6.6
Columbia-North Pacific	381	28.3	710,123	12.1
Alaska[2]	19	ND	ND	ND
Great Lakes	2,237	46.5	4,309,379	8.8
Hawaii[2]	13	ND	ND	ND
Caribbean[2]	19	ND	ND	ND
Total	6,733			

Source: Recreational Boating in the Continental U.S. in 1973: The Nationwide Boating Survey, Rep. No. 745103, U. S. Coast Guard, Department of Transportation (October 1974).
[1]Total data for those counties contiguous to marine waters were included.
[2]Calculated from Numbered Boats by States, The Boating Business 1974, Boating Industry, (February 1975).
ND, No data available.

There were approximately 353 thousand boat parking spaces and almost 432 thousand slips and mooring spaces in the U.S. in 1965 (Table 3.12). Over 34 percent of the parking spaces and 36 percent of the slips and mooring spaces were located in the South.

Table 3.12. Boating Installations by Regions, 1965.

Region[2]	Marinas (1,000)	Boat Parking Spaces[1] (1,000)	Slips & Mooring Spaces[1] (1,000)
Northeast	3.2	41.6	101.6
South	14.0	120.5	154.4
West	12.4	85.9	65.5
Total (U.S.)	35.6	352.8	431.9

Source: Nationwide Outdoor Recreation Plan, Draft report prepared by U.S. Department of Interior, U.S. Senate Committee Print, 93rd Congress, 2nd Session (September 1974), p. 115.
[1]Includes both public and private spaces.
[2]Regions:
Northeast: Maine, New Hampshire, Rhode Island, Massachusetts, Pennsylvania, Vermont.
South: Delaware, Maryland, West Virginia, Virginia, Tennessee, Kentucky, North Carolina, South Carolina, Georgia, Alabama, Florida, Arkansas, Louisiana, Texas, Oklahoma, Mississippi.
West: California, Oregon, Washington, Nevada, Idaho, Montana, Wyoming, Colorado, Utah, New Mexico, Arizona.

CONFLICT AREAS

Conflicts exist among many users and uses of the estuarine resources. In some regions allocation conflicts exist between commercial fishing fleets, between commercial and sport fishing, and commercial and subsistence fishing. Other conflicts involve recreational and economic development activities.

Domestic versus Foreign Fleets

Since World War II, fishing fleets from numerous nations have extended their fishing activities into fisheries off the coast of the U.S. Roedel (69, p.4) puts the concern into perspective: "We are dealing basically with allocation conflicts. Some of them involve different countries fishing the same resource. Some of them are between States in the contiguous fishery zones."

According to Norris (69, p.13), the total catch in the Northwest Atlantic increased from 1.8 million metric tons in 1954 to 3.9 million in 1968. The increased catch is almost entirely due to increased fishing by European countries. The U.S. and Canadian catches in the same period increased from 1.2 million to only 1.5 million metric tons. He also states that cod are now being fished at or beyond the level which will provide the maximum sustained yield. Some stocks of herring are now overfished. Total fish stocks in the Northwest Atlantic cannot withstand further increases in fishing without being overexploited to the extent of reducing actual yields. Haddock and yellowtail flounder in New England have been affected greatly by increased foreign fishing. Biologists estimate that the early sixties catch was close to the maximum sustainable yield of 50,000 metric tons of haddock. For flounder, the U.S. catch alone has exceeded in some years the estimated maximum sustainable yield.

McHugh (102) reports that fishery resources of the area from Cape Cod to Cape Hatteras provided a domestic commercial catch in 1973 of about 1.6 billion pounds, for which American fishermen received about $119 million. They also provided 820 million pounds to fishing fleets of at least 10 other nations. The sport catch in the area was probably greater than 447 million pounds. Foreign fishing became a serious problem in 1966 when the Soviet Union, having taken a large harvest from the strong 1963 year class of haddock on Georges Bank, began to extend its operation to the south and west. Of 47 major species, 18 are also being taken by foreign fleets.

McHugh (102) summarizes the foreign catch as having had a measurable adverse effect on some fishery resources of interest to domestic commercial and recreational fishermen. However, a number of important fishery resources of the Middle Atlantic estuarine area are not subject to foreign fishing and stocks of these have declined in the last five years much more sharply than some which are taken by foreign fleets. The fact does not mean that foreign fishing is not having its effects, but it does emphasize the complexities of the situation and the need to pay serious attention to domestic fishery management.

According to Tillion (36) about 89 percent of the total living resources from the coast and seas bordering Alaska have been caught by foreign nationals of the Russian, Japanese and, to some extent, Korean high seas fishing fleets. In addition, the Japanese have invested heavily in Alaskan fisheries. One of the oldest, B&B Fisheries of Kodiak, represents an investment of $2.5 million. The plant has been in operation since 1967 as a crab processor, but handles scallops, shrimp, halibut, salmon, and roe as well. Taiyo Fisheries of Japan operates in both Cordova and Kodiak with an investment of $2.5 million. The firm is principally interested in purchasing salmon, salmon roe, shrimp, crab, herring, and herring roe. Smaller companies are also present in Alaska. While the Japanese buyer on the one hand has helped the rise in the price of fish, it does not make up in the eyes of the fishermen for the loss in the number of fish. An additional impact to the Pacific fisheries is the East German and Polish vessels now operating off the Washington and Oregon coasts.

Unlike the fisheries off the Atlantic, Pacific, and Alaskan coasts, the fisheries of the Southeast Region have not suffered from massive foreign fishing. However, longline fishing in the Gulf by other countries has created some fears of future depletion of larger finfish in these waters (92).

Commercial versus Sport Fishing

According to Poff (114) many fish stocks in Lake Michigan are now either fully exploited or over-exploited. Conflicts between the two major segments utilizing the fishery and its fish stock, sport and commercial, are increasingly vocal. The chub fishery represents the heart of the commercial fishery. Since 1968, chub production in these waters has declined markedly, dropping from 6.2 million pounds in 1968 to 2.2 million pounds in 1972. Sport fishermen have fought strenuously for increased restriction on commercial fishing. Commercial fishermen have vigorously defended their right to take fish as they have for years (44).

Hopkins and Petrocelli (98) indicate that the greatest restrictions on commercial fisheries in the Gulf of Mexico are those demanded by sport fishermen to maintain a monopoly for themselves. Pressure from sport fishermen has resulted in closing Texas bays to commercial netting for fish. There is even a current movement in Texas to outlaw the sale of such marine fishes as spotted trout and red drum because they are "game fishes" (98, p.11).

Subsistence versus Commercial Harvest

A high priority conflict problem exists in Alaska among subsistence use and other users of estuarine resources. According to Watson and

Wentworth (87), high dependency on subsistence fish exists in the Bering coastal area but not along the Arctic coast. There is also a heavy dependency on marine mammals in the Bering coastal area. The major portion of the food consumed by the people and their dogs in the Yukon-Kuskokwim Delta comes from wildlife resources; fuel comes from seal oil, clothing is made from hides of the marine and land mammals of the area. Seal hunting is of greatest importance in the villages of Scammon Bay, Hooper Bay, and Fanunak.

The Land Use Planning Commission for Alaska (6, p.3) states that while there have been no restrictions placed on subsistence fishing, these fishermen want to participate in larger and larger commercial harvests. Thus, according to the Commission, fisheries regulations must include the subsistence fishermen.

Table 3.13 provides a summary by region of identified present and near-term threats among the commercial, foreign, sport, and subsistence fishery acitvities. Threats from foreign fishing fleets is high in the New England, Middle Atlantic, Columbia-North Pacific, and Alaskan regions. Threats from sport fishing are high in the Great Lakes and Texas Gulf regions. Threats from subsistence fishing are high in Alaska and in some instances in the Columbia-North Pacific regions. Threats may exist in other regions but were not identified in the available literature.

Table 3.13. Present and Near-Term Threats to Fish or Wildlife Harvest by Water Resource Regions.

	Harvest (Quantity and Values)		
Region	Sport vs. Commercial	Domestic vs. Foreign	Subsistence vs. Others
New England		H	
Middle Atlantic	S	H	
South Atlantic		A	
East Gulf		S	
Lower Mississippi			
Texas-Gulf	H	S	
California-South Pacific	S		
Columbia-North Pacific		H	H
Alaska		H	H
Great Lakes	H		
Hawaii			S

H, a high degree of conflict has been identified.
S, some degree of conflict has been identified.
A, an absence of conflict has been identified.
Blanks indicate that inadequate information is available for making an evaluation.

Recreational Activities

In addition to the commercial-sport, domestic-foreign, and subsistence-commercial conflicts, locational conflicts occur among these and other estuarine activities. Demands for mooring space along the shoreline can result in disputes with other potential shore users such as estuarine-based industry, housing developments, commercial sea transportation facilities, nuclear and desalination facilities, and recreational facilities. Fish processing and packaging plants have historically been considered objectionable waterfront users and have competed for space with most industrial and port-oriented activities.

Locational conflicts and congestion problems develop at sea due to the occasional common space requirements of the fishing industry, offshore mining and petroleum operations, the water transportation industry, and various recreational uses. The proximity of other estuarine activities such as dredging and filling, industrial and domestic sewage disposal, pollution from mining and petroleum facilities, power plant facilities, and water diversion projects can have an adverse impact on commercial fishing and mariculture activities.

Locational conflicts for recreational activities are greatest where the demand for more recreational facilities is greatest - in and near urban areas. Sportfishing and angling activities often conflict with other shoreline recreational activities such as swimming, boating, and surfing in addition to commercial fishing, harbor development, and industrial, commercial, and shipping interests. If water quality deteriorates, there may be a gradual replacement of highly desirable game fish by less desirable species. Extreme pollution renders the water totally uninhabitable. Dredging and filling operations are especially damaging to activities associated with sport fishing as well as wildlife.

In a recent study (38), researchers estimate that with the continuing increase in population, leisure, income, and mobility, the demands for shoreline recreation should triple before the turn of the century. This increase is of major concern when we consider that our public coastal facilities are already filled to capacity while there is no room left for expansion through acquisition and development.

A recent review (56) of the state-of-the-art in knowledge of boating effects on the environment, effects of facility construction, and environmental and recreational carrying capacity indicates that recreational boating activities in the Chesapeake Bay may potentially conflict with commercial shipping, commercial fishing, vehicular transportation, private shorefront property use, and other shore-oriented recreational pursuits such as swimming and fishing. Power recreational boating activities should be regulated in shellfish and fish spawning areas during critical stages. The effect of increased boat traffic on vehicular traffic flows must be considered. Location of marinas and launching ramps on salt marshes and scenic shorelines proclaim a status of misuse and degradation of socially valuable resources.

The impact of Alaska's current oil boom on waterfowl populations and wetlands habitats is slight at present (4). Perhaps the greatest threat to Alaska's waterfowl populations from North Slope oil is associated with the terminus of this pipeline at Valdez on Prince William Sound. Here, increased petroleum shipping constitutes a definite hazard to breeding populations of the Dusky Canada Goose and other waterfowl, and to ducks, geese, and other waterbirds moving through this area during spring and fall migration periods. The consequences of activities in Cook Inlet are minimal and probably will continue to be of negligible importance to overall waterfowl populations.

Summary of Conflicts

As shown in Table 3.14, many estuarine environmental conditions have a high adverse effect on fishery harvest, wildlife harvest, and non-consumptive uses. Pollution conditions have a high adverse effect for each of these activities. Other impacts range to a very low adverse effect such as the impact of shoreline congestion on commercial fisheries. Likewise, turbidity and salinity conditions have a very low impact on non-consumptive uses but a high impact on commercial fisheries.

Table 3.14. Relative Degree to Which Estuarine Environmental Conditions Adversely Affect Estuarine Activity.

Activity	Shoreline Congestion	Water Surface Congestion	Pollution	Turbidity and Salinity	Topo-graphical Alteration	Ecological Damage	Aesthetic Damage
Commercial Fisheries							
Finfish	L	M	H	H	H	H	VL
Shellfish	L	M	H	H	H	H	VL
Aquaculture	L	M	H	H	H	H	VL
Recreation							
Sportfishing	L	H	H	H	M	H	M
Boating	M	H	H	M	VL	L	H
Wildlife Harvest[1]							
Ducks and Geese	H	VL	H	VL	H	L	VL
Animals	H	VL	H	VL	H	L	VL
Non-Consumptive Uses[1]							
Bird Watching	H	VL	H	VL	M	VL	H
Photography	H	M	H	VL	H	H	H
Nature Walks	H	VL	H	VL	M	VL	H

Source: Portions from National Estuary Study, U. S. Fish and Wildlife Service (January 1970), p. 94.
H, high adverse effect.
M, medium adverse effect.
L, low adverse effect.
VL, very low adverse effect.
[1]Judgments of authors.

Table 3.15 provides an indication of the degree of compatibility among potential activites and commercial fisheries, recreation, and wildlife harvest. Some activities have a very low compatibility with other activities. Examples of this situation include aquaculture and channels, and wildlife harvest and urbanization activities. Nevertheless, a high degree of compatibility exists for many users of the estuarine resources.

Table 3.15. Degree of Compatibility Among Estuarine Uses.

Introduced Activity	Commercial Fisheries Finfish	Commercial Fisheries Shellfish	Commercial Fisheries Aquaculture	Recreation Sport Fishing	Recreation Boating	Wildlife Harvest[1]
Transportation						
Vessels	H	H	L	H	H	H
Channels	H	M	VL	H	H	L
Port Facility	H	H	H	H	H	M
Commercial Fishing						
Finfish				L	L	H
Shellfish				L	M	M
Aquaculture				L	M	M
Extractive						
Petroleum	M	H	H	H	H	H
Solution Mining	H	H	H	H	H	H
Bottom Mining	H	M	M	H	H	H
Water Utilization						
Power Facility	H	H	H	H	H	L
Desalination	H	H	H	H	H	M
Sewage Disposal	H	H	H	H	H	L
Urbanization						
Housing	H	H	H	H	H	VL
Commerce-Industry	H	H	H	H	H	VL
Highway (etc.)	H	H	H	H	H	VL
Recreation						
Sportfishing	L	M	M		M	H
Swimming	L	M	L	L	M	M
Boating	L	M	M	M		M
Miscellaneous	M	M	M	M	H	M

Source: Portions from National Estuary Study, U. S. Fish and Wildlife Service (January 1970), p. 94.
H, high compatibility
M, medium compatibility
L, low compatibility
VL, very low compatibility
[1]Judgment of authors.

FUTURE HARVEST PROJECTIONS

Relatively little information has been published or otherwise made available relative to future regional demand for fish (a notable exception is Bell (67)) and wildlife harvest. Even less information is available concerning the ability of the marine related resources to meet present or increased demands.

Demand for Fisheries Products

Implementation of management systems consistent with optimum yield, importation of fish products, and the 200-mile limit legislation will have an appreciable but as yet unknown impact on the ability of the estuarine systems to meet future demands. Nevertheless, one can use projected increases in population, per capita income, and present per capita consumption to project future demands on marine resources and uses. In most cases, per capita consumption will also depend on substitutability of other competing products.

Per Capita Consumption

Present per capita consumption of fish products varies appreciably by category and by region. As shown in Table 3.16, Nash found per capita consumption of specialty items to be lowest in the East North Central, South Atlantic and East South Central regions (68). New England and the Middle Atlantic regions had the highest per capita consumption of these items. Per capita consumption of shellfish was much higher in the Northeast Region than in other regions. Per capita consumption of finfish was substantially higher in the South Central regions which include the Gulf areas. Consumption of canned fish was highest in the New England and South Central regions.

Table 3.16. Per Capita Consumption of Selected Species by Regions and Per Capita Income, February 1969 - January 1970.

Region[1]	Specialty Items[2]	Shellfish[3]	Finfish[3]	Canned Fish
	Pounds per Capita			
New England	1.97	4.16	5.80	17.60
Middle Atlantic	1.96	2.03	4.64	14.29
East North Central	1.18	1.19	3.51	10.04
South Atlantic	1.36	2.20	5.38	14.22
East South Central	1.06	1.91	7.49	17.24
West South Central	1.78	1.63	8.63	16.56
Pacific	1.89	1.71	4.43	13.96
Per Capita Income $				
Under 1,000	.71	.82	4.16	10.97
1,000-1,999	1.28	1.78	4.38	12.57
2,000-2,499	1.25	.98	2.82	9.23
2,500-2,999	1.18	2.46	4.72	14.02
3,000-3,499	1.67	1.95	4.79	13.02
3,500-over	1.71	2.03	3.89	12.66

Source: A Survey of Fish Purchases by Socio-Economic Characteristics, Working Paper No. 50, Bureau of Commercial Fisheries, U. S. Department of Commerce (April 1970).
[1]For census geographic divisions, see footnote 1, Table 3.7.
[2]Includes tuna pie, clam chowder, oyster stew, TV dinners, smoked fish, others.
[3]Includes both fresh and frozen.

The Sport Fishing Institute (58, p.7) estimates that edible weight of saltwater fishes taken by anglers is equivalent to approximately one-fourth the amount of edible fish reported entering the national diet through all channels in 1973. This consumption is in addition to the reported per capita consumption of 12.6 pounds of seafood in 1973. Consumption consisted of edible fish (fresh, frozen, canned, or cured) that entered usual commercial channels from all sources, and represents about 2.6 billion pounds of fish.

As shown in Table 3.16, per capita consumption of specialty items generally increased at higher levels of per capita income. Per capita consumption doubles between a per capita income level of $1,000 and over $3,500. Likewise, per capita consumption of shellfish generally increases at the higher level of per capita income. A trend in per capita consumption of finfish is not evident in the available data. There is a slight increase in consumption of canned fish at higher levels of income.

While the data in Table 3.16 do not indicate a clear trend in per capita consumption as a result of different levels of per capita income, the income elasticity of some estuarine species indicates a significant increase in per capita consumption with an increase in income. The income elasticity for lobster is reported to be 2.1, shrimp 1.8, fresh and frozen salmon 1.6, crab 1.3, and groundfish 1.2 (84, p.19). For example, as income increases by one percent, consumption of lobster will increase by 2.1 percent. Negative elasticities have been reported for oyster, salmon, and halibut (10).

Information on trends in per capita consumption is inadequate for making predictions on future consumption of fish products. However, if we assume that per capita consumption remains constant, the fact that population is projected to increase for each region will result in an increase in total consumption of fishery products. Also, projected changes in relative per capita income will have an impact on consumption.

Population and Income Projections

Population and income projections for 1985 and 2000 by counties in Water Resource Council Regions which are adjacent to estuarine and nearshore systems were provided by WRC primarily for use in the 1975 assessment (108). Increases in both population and per capita income result in growing demands for commercial and recreational use of coastal zone resources and at the same time often intensify problems of pollution and quality degradation. According to Spangler, "that almost half of the total personal income of the United States is forecast to accrue to 76 coastal metropolitan areas by 1980 is of considerable importance in assessing the effect upon limited resources of a fairly concentrated segment of the U.S. population in the coastal zone" (35).

The total population for the estuarine area counties for 1975 is estimated to be 153 million or 71.8 percent of the 213 million U. S. totals. The percentage change of estuarine area population is projected to increase by 10.69 percent by 1985 and 13.54 percent between 1985 and 2000 compared to the U.S. increase of 9.93 percent and 12.50 percent, respectively (Appendix 3). A large degree of variability exists among regional increases in population. The estimated increase in population between 1975-1985 for the Columbia-North Pacific Region is only 4.30 percent compared to 16.51 for the South Atlantic and 17.70 percent for Alaska (Table 3.17). The population increases between 1985-2000 are a low of 5.55 percent for the Lower Mississippi compared to 19.87 for the South Atlantic and 21.33 percent for Alaska. Thus, excluding Alaska, available data indicate that the fastest growing estuarine area is the South Atlantic Region which includes North Carolina, South Carolina, Georgia, and the eastern part of Florida.

Table 3.17. Projected Change in Population and Income for Central Case by Water Resource Regions.

Region	Percent Change in Population 1975-1985	1985-2000	Change in Relative Per Capita Income[1] 1975-1985	1985-2000
New England	8.96	12.49	-	-
Middle Atlantic	10.76	13.83	-.01	-.02
South Atlantic	16.51	19.87	.02	.02
East Gulf	13.81	15.84	.02	.02
Lower Mississippi	5.43	5.55	.01	.03
Texas-Gulf	12.63	15.62	-	.01
California-South Pacific	12.02	14.30	-.02	-.02
Columbia-North Pacific	4.30	8.56	.02	.01
Alaska	17.70	21.33	-.04	-.03
Great Lakes	8.11	10.64	-	-.01
Hawaii	15.72	19.16	-.05	-.03
U. S.	9.93	12.50	-	-

Source: See Appendices 3 and 4. Calculated from "Series E" Projections and Historical Data, Population, Personal Income and Earnings, Aggregated Subareas, U. S. Water Resources Council (June 1974).

[1]These values are based on region per capita income relative to the U. S. per capita income. For example, per capita income for the U. S. in 1975 is $4,070 and in 1985 is projected to be $5,429. For the South Atlantic Region it is $3,437 and $4,640 respectively or 3,437 divided by 4,070 equals 0.84 and 4,640 divided by 5,429 equals 0.86. This represents an increase in relative per capita income of (0.86-0.84) 0.02 points.

Coastal regions differ widely in per capita personal income and per capita income relative to the U.S. average (Appendix 4). Geographic distinction was more noticeable with the South Atlantic-East Gulf and Lower Mississippi regions appreciably lower than the 1975 U.S. average of $4,070 per capita income. The relative position of these areas is projected to be the same in year 2000. Nevertheless, the relative per capita income (as a percentage of U.S. per capita income) for the Lower Mississippi is projected to increase from .77 to .81 and for the South Atlantic-East Gulf from .84 to .88 (Table 3.17). The Middle Atlantic, California-South Pacific, Alaska, and Hawaii regions are projected to have a decrease in relative per capita income.

Projected Increases in Consumption

Based on alternative futures for the Central Case, the largest projected increase in population between 1975, 1985, and 2000 will occur in Alaska with a total increase of 39 percent for the two periods while relative per capita income will decrease by .07 points - a significant decrease in relative per capita income. Based on an assumption of constant per capita consumption, the increase in consumption of fishery products due to increases in population will be offset to some degree by a decrease in relative per capita income. The ability of the estuarine system to support a 30 percent increase in consumption will depend on several variables including management plans.

Both the South Atlantic and East Gulf regions will experience a significant increase in fish/shellfish consumption. The South Atlantic Region has a projected increase in population of 36.28 percent for the 1975-1985 and 1985-2000 periods. This region is projected to receive an increase of .04 points in relative per capita income. The East Gulf Region will experience an increase in population of 29.65 percent and .04 points in relative per capita income. Both of these regions have a low consumption of speciality items but high consumption of finfish and canned fish. The positive change in per capita income will reinforce the increased consumption (nearly 40 percent) resulting from population increases.

The smallest gains in population are projected for the Lower Mississippi and Columbia-North Pacific regions. However, both regions will experience significant increases in relative per capita income. The Columbia-North Pacific Region has a relatively high per capita consumption of all seafood products particularly specialty items. The Lower Mississippi Region has comparatively high per capita consumption of both finfish and canned fish. Even with the low projections for population increases, the high per capita consumptions and increases in per capita income should result in an increase in consumption of more than 10 percent.

The alternative futures based on increases in population and changes in income between 1975-1985 and 1985-2000 indicate that the Alaska, Hawaii, South Atlantic, and East Gulf regions are the regions which will experience the greatest potential future impact. The Lower Mississippi and Columbia-North Pacific regions will experience the smallest potential future impact.

Supply of Fishery Products

An important factor in projecting the consumption of fish products is a knowledge of optimal yields of various species for each estuarine region. Potential future supply of the fish species will have a significant impact on price and thus a significant impact on consumption. A second factor is the substitutability of imported fish products.

Policy decisions must balance future potential harvest with future yield of species by estuarine systems. Traditional marine fisheries science has used the concept of maximum-sustained yield (MSY) management of fish populations. A U.S. Senate Committee reported:

> "The maximum sustainable yield is achieved when the annual catch is at the highest level (in terms of number or weight of fish caught) which can be sustained without harming the reproductive ability of the stock. However, many experts believe that use of the maximum sustainable biological yield objective in fisheries management may lead to substantial economic waste and may ignore important environmental relationships between stocks from which yield cannot be maximized simultaneously. It seems more desirable therefore to adopt the objectives of optimum yield defined to include biological, economic, and environmental factors as the guideline for fishery management in an extended fishery zone and over anadromous species of fish" (65, p.22).

Increases in fishing effort, with accompanying conflicts of interest, have led to depletion of a number of important U.S. fisheries stocks, either as a whole or in particular areas. As shown in Appendix 5, the National Marine Fisheries Service (74) provides a present estimate of the status of major U.S. stocks. The report shows that herring, mackerel, and shrimp, among others, have been overfished. Crab, lobster, menhaden, and shrimp are now being fully utilized. A large number of species is listed as having a potential for increased catch.

The National Marine Fisheries Service (71,74) has provided an estimate of MSY for selected species (Table 3.18) and the demand and supply of market classes between 1973 and 1985 (Table 3.19). Available data on recreational demand were included. Data are based on present estimates and are not considered to be exact. Forecasts are provided for consumption of edible fisheries products in eleven market classes in the absence of any changes in present trends and circumstances. The potential increase by market classes in Table 3.19 indicates the general potential of U. S. fisheries to contribute to our future needs.

Table 3.18. Projected Maximum Sustainable Yield for Selected Species by Ocean Areas.

Species	Ocean Area	MSY (1,000 tons)
Shrimp	Northwest	30
	Atlantic West Central	177
	North Pacific	144
Blue Crab	Atlantic West Central	89
Oysters	Atlantic	363,889
	Pacific	42,889
Salmon		
Chinook	Pacific	25
Chum	Pacific	39
Coho	Pacific	39
Pink	Pacific	111
Sockeye	Pacific	66
Atlantic	Atlantic	13.3
Trout	Atlantic	19.4
Menhaden	Atlantic	444-555
	Gulf of Mexico	455
Dungeness Crab	North Pacific	50
King Crab	North Pacific	100

Source: Current Fisheries Statistics Nos. 5934, 6129, 6132, 6131 and 6273, National Marine Fisheries Service, NOAA (1973-74).

Table 3.19. Demand and Supply of Fishery Products by Market Class between 1973 and 1985[1].

Market Class	Demand: Increased Need by 1985 Commercial	Recreational	Total	U. S. Supply: U. S. 1973 Landings	MSY	Potential Increase
Groundfish	1,079	399	1,418	419	7,502	7,083
Halibut	39	ND	39	24	62	38
Tuna	341	32	373	515	2,902	2,387
Salmon	66	24	90	213	303[2]	90[2]
Scallop	13	ND	13	9	36	27
Shrimp	245	ND	245	372	599	227
Lobster	42	ND	42	41	44[2]	3[2]
Crabs	10	ND	10	235	515	280
Clams	40	ND	40	106	255[2]	149[2]
Oysters	20	ND	20	49	137[2]	88[2]

Source: National Fisheries Plan: Review Paper on Issues and Options, National Marine Fisheries Service, NOAA (April 1975), p. 21.
[1]In millions of pounds, round weight, except for univalve and bivalve mollusks which are weight of meats.
[2]Includes increased production from aquaculture.
ND, No data available.

As shown in Table 3.19, ample resources of groundfish exist to supply future U.S. increases and possibly displace some present imports. The estimated supply increase in salmon by 1985 is 90 million pounds. With adequate supplies, it is probable that U.S. consumption would increase well above the predicted amounts. Scallop resources presently available to U.S. fishermen are sufficient to provide for projected increases if distribution and abundance of the resource can be monitored.

According to the NMFS report (74), with an increase in demand of 245 million pounds, the unfished shrimp resources off the U.S. amount to 227 million pounds, but much of this is the smaller, lower valued shrimp that would not replace the demand for larger shrimp. Although aquaculture offers a prospect for increased shrimp, imports of shrimp will need to be increased.

The potential for increases in supply of lobster is small. Inshore lobster resources are probably being over-exploited. Offshore lobster stocks have declined. Only small increases in imports are likely. The estimated increase needed by 1985 is 42 million pounds but potential increase in supply is projected to be only 3 million pounds (Table 3.19).

Adequate potential increases in U.S. supply exist to meet the expected increase in demand for crabs, clams, and oysters. High cost is now a limiting factor in the harvest of an estimated 280 million pounds of crabs that are available but currently not being harvested. Traditionally harvested stocks of clams are fully utilized. However, U.S. supplies exist to meet future needs if logistics problems in Alaska and if pollution problems in Alaska and the Atlantic coast can be controlled.

A comparison of MSY and current landings of each species for each region is not presently available. However, published information does indicate that stocks of certain species such as cod, haddock, yellowtail flounder and shrimp are being over-exploited in the Northeast waters (69, 85, 102). Fish stocks, particularly chub, are being over-exploited in the Great Lakes (114). Depletion of larger finfish has created problems in the Gulf (92).

A recent legislative report indicates that Alaska's unmanaged commercial fishing for red, pink, chum, coho, and king salmon has impaired or threatened to impair the harvest of these Alaskan fishery resources (8).

Other studies have attempted to measure future yield of certain species in selected areas. According to a report by the New Hampshire Fish and Game Department (47), harvest of lobster is estimated to remain relatively static in the next decade. The advent of limited entry and increased size limits could result in modest but valuable increases in harvest in the 1980-1990 period. Harvest of shrimp in New Hampshire is expected to decrease slightly during the next decade either due to regulations or from over-exploitation.

The future of the New Hampshire gill net fishery depends a great deal on the establishment of a 200 mile fisheries zone along the Atlantic coast. According to the report (47), haddock have been eliminated by foreign fishing fleets. Yellowtail, herring, cod, and mackerel fisheries are endangered. Establishment of a 200 mile fisheries zone within the next year or two may save the cod, the mainstay of the gill net fishery.

The demand for commercial fishing is expected to almost double by 2020 in the Pacific Northwest River Basin (105). Commercial harvest of anadromous and marine fish and shellfish is projected to increase to about 270 million pounds by 1980, 357 million by 2000.

Recreation and Hunting Demands

Kalter (99) provides a summary of projected increases in recreational activities including fishing and nature walks between 1972 and 1978 for those Bureau of Economic Analysis (BEA) areas which are adjacent to the national estuarine zone. With a projected increase of 8.1 percent in population for these areas, an increase is expected in activity days of 9.8 percent for recreational fishing, 17 percent for boating (other than water skiing and sailing), and 14 percent for nature walks (Table 3.20).

According to Kalter's analysis, the recreational activity in greatest demand is swimming (other than pools) followed by fishing, nature walks, boating (other than skiing and sailing), and water skiing. On a regional basis, boating ranks ahead of nature walks in the South Atlantic, East South Central, and West South Central areas. The greatest amount of demand is for fishing in the Pacific and South Atlantic areas.

Table 3.20. *Summer of 1972 and Percentage Increase for 1978 in Selected Outdoor Recreation Activities in Business Economic Areas (BEA) Adjacent to National Estuarine Zone.*

BEA Area[1]	% Increase in Population 1972-1978	Fishing: 1972 Activity Days (1,000)	Fishing: % Increase 1978	Boating: 1972 Activity Days (1,000)	Boating: % Increase 1978	Nature Walks: 1972 Activity Days (1,000)	Nature Walks: % Increase 1978
New England	9.0	9,752	11.5	5,531	18	6,461	15
Middle Atlantic	8.5	18,989	11.5	10,688	23	13,374	18
South Atlantic	7.9	32,873	9.4	12,664	17	9,976	14
East South Central	8.0	1,266	9.0	432	16	347	13
West South Central	6.1	14,200	7.4	5,106	15	4,195	12
Pacific	9.7	32,916	11.6	14,603	18	28,054	14
Total or Average (U.S.)	8.1	109,995	9.8	49,045	17	62,409	14

Source: Recreational Activities in the Nation's Estuarine Zone, by Robert J. Kalter in Estuarine Pollution: A National Assessment, U. S. Environmental Protection Agency, Washington, D. C. (1975).

[1]BEA, Business Economic Areas:

New England: Bangor, Portland, Boston, Hartford.
Middle Atlantic: New York, Philadelphia.
South Atlantic: Baltimore, Washington, Richmond, Norfolk, Raleigh, Wilmington, Florence, Charleston, Savannah, Jacksonville, Orlando, Miami, Tampa, Tallahassee, Pensacola.
East South Central: Mobile.
West South Central: New Orleans, Lake Charles, Beaumont, Houston, San Antonio, Corpus Christi, McAllen.
Pacific: Seattle, Portland, Eugene, San Diego, Los Angeles, Eureka, San Francisco.

The outdoor recreation activities currently in greatest demand are not necessarily those which are expected to grow the fastest in the future. For the whole U.S. boating is expected to increase fastest between 1972 and 1978 at a rate of 17 percent. In addition to the high increase in boating demand in each area, the greatest increase in these activities for each estuarine zone is water skiing in the Middle Atlantic area with an increase of 25 percent.

The data indicate that many of the areas which show the greatest levels of demand are also the areas which show some of the highest projected increases in demand between 1972 and 1978. Even when a rapid rate of growth in demand is associated with lower initial levels of demand, the growth rate may be enough to create significant strains on the ability of the estuarine resources to absorb the increases. The greatest strain will be on boating (other than skiing) resources in estuarine zones.

Kalter's projections were limited to the period 1972-1978 and were estimated only for selected metropolitan areas within each area. If we assume current consumptive patterns will continue we can project future consumption for the Central Case in 1985 and 2000. Based on population projections, the largest increases will occur in the South Atlantic Region. This area currently has the highest number of saltwater anglers and fishing activity days. The population increase is expected to be approximately 40 percent between 1975 and 2000.

Based on population projections for the period between 1975-1985 and 1985-2000, activity days in sport fishing and other recreational activities are expected to increase by as much as 40 percent in the South Atlantic, Alaska, and Hawaii regions. The increase should be over 20 percent for the New England, Middle Atlantic, East Gulf, Texas-Gulf, and California-South Pacific regions. The increase in demand for recreational activity days should be over 10 percent for the Great Lakes, Lower Mississippi, and Columbia-North Pacific regions. As workers acquire more leisure time the percentage of time allocated to recreational activities is also expected to increase. Thus, the increase in demand could be much greater than the increase in population.

"Although there is a significant lack of available data upon which to formulate the future outlook of estuarine-associated hunting it appears that the relative importance of this activity will decline appreciably in the future, particularly as access and availability of suitable sites near populated areas decline" (84, p.36). The above statement was made in the 1970 estuarine study and appears to accurately portray the current situation. A 1974 administrative report of the U.S. Fish and Wildlife Service (86) shows duck stamp sales in 1973 were approximately 11 percent lower than in 1972. U.S. waterfowl hunters spent 12 percent fewer days hunting and bagged 20 percent fewer ducks, 36 percent fewer coots but 25 percent more geese than in 1972.

The Department of the Interior (78) indicates that birdwatching participants will increase from 9 million in 1965 to 13 million in 1980 and to 19 million in 2000. The estimate of increase in bird and wildlife photography is from 3 million in 1965 to 5 million in 1980 and to 8 million in 2000.

Selected studies have estimated increases in recreation for specific estuarine areas. In a study of the recreational needs for the Chesapeake Bay (77, p.17), the U.S. Bureau of Outdoor Recreation estimates that demand for boating activity day per year will increase by 36 percent between 1970 and 1980 and by 32 percent between 1980 and 2000. The author estimates that boating and sailing acreage is sufficient to maintain a surplus of supply but a shortage will exist in boat mooring and slips.

Sportfishing and hunting demand in the Pacific Northwest River Basins is expected to increase 154 percent and 112 percent, respectively, by 2020. Sportfishing needs are projected to increase from about 21 million angler days in 1970 to about 32 million per year by 1980, 45 million by 2000. This includes recreational use of anadromous, resident, marine, and shellfish species (105).

In New Hampshire, the number of saltwater sportfishing days can be expected to exceed 250,000, valued at over $5 million in the 1975-1980 period. The man days of saltwater sport fishing can be expected to increase to 350,000 annually at a value of over $7 million during the period 1980-1990.

Based on analyses by Clark (95) the number of people sport fishing has increased 50 percent since 1960, while the yearly catch of each fisherman has declined somewhat. As number of anglers increased from 6.2 million to 9.4, the yearly average catch dropped from 102 fish to 87 fish per angler.

Recreation Water Supply

A substantial portion of the water area available for recreation is encompassed by the estuarine zone. Yet, 59 percent of the area remains underdeveloped and over 70 percent resides in private ownership. About 25 percent of the area is used for recreation (99, p.1).

Current capacity and future facility needs cannot be identified from available data. More importantly, it is obvious that recreational sites other than those located in estuary zones could serve as supply sources for this demand (99, p.25). Capacity can obviously vary for a given site due to intensity of use. Two other factors, quality of recreation experience offered and activity mix at the site, are important to a determination of supply. The existence of complementary and competitive activities can affect the overall capacity level at a site.

CHAPTER 4
IMPACTS OF PREDICTED WATER RESOURCE UTILIZATION

J. E. Warinner, M. P. Lynch

INTRODUCTION

A major aim of the 1975 Water Resources Assessment is to predict the impact of projected water uses for the years 1985 and 2000. In this chapter, we have attempted to predict the impact of water use and supply projections on estuarine and nearshore environments. For this purpose, the water use and supply projections for the years 1975, 1985, and 2000 were obtained from the U. S. Water Resources Council for all of the Aggregated Subareas (ASA) which terminate in estuaries or coastal areas including the Great Lakes. The following assumptions were made in developing the Central Case future condition set of water-related requirements by the Water Resources Council (WRC).

1. Population and Economic Activity. As contained in the OBERS "E" Series Report (108).
2. Agricultural and Forestry Production. As contained in the OBERS "E" Series Report (108).
3. Water Quality. The 1983 Water Quality Goals will be achieved by 1985.
4. Water Use. Unit withdrawal and consumptive use rates will change from the 1975 rates as a result of achieving the 1983 Water Quality Goals by 1985.
5. Electric Power. Per capita electric power consumption will continue along current trends.
6. Flood Damages. The 1975 level of flood plain regulation will remain constant into the future.
7. Navigation. Current trends in the relative magnitude of waterway shipments to total shipments will continue into the future.
8. Fish and Wildlife. Current trends in per capita demand for angler and water related hunter days will continue into the future.
9. Recreation. Current trends in per capita demand for water related recreation will continue into the future.
10. Energy. Import of minerals will continue at a somewhat reduced rate of growth.

Although originally charged with only dealing with projections for Water Resource Regions, it quickly became evident that regional summaries were not sensitive to specific problem areas, so a decision was made to deal with the use and supply data aggregated at the ASA level.

DEMAND/SUPPLY

Our approach to this analysis was based on assessing the effects of changing demands for fresh water on the freshwater discharge into the estuaries.

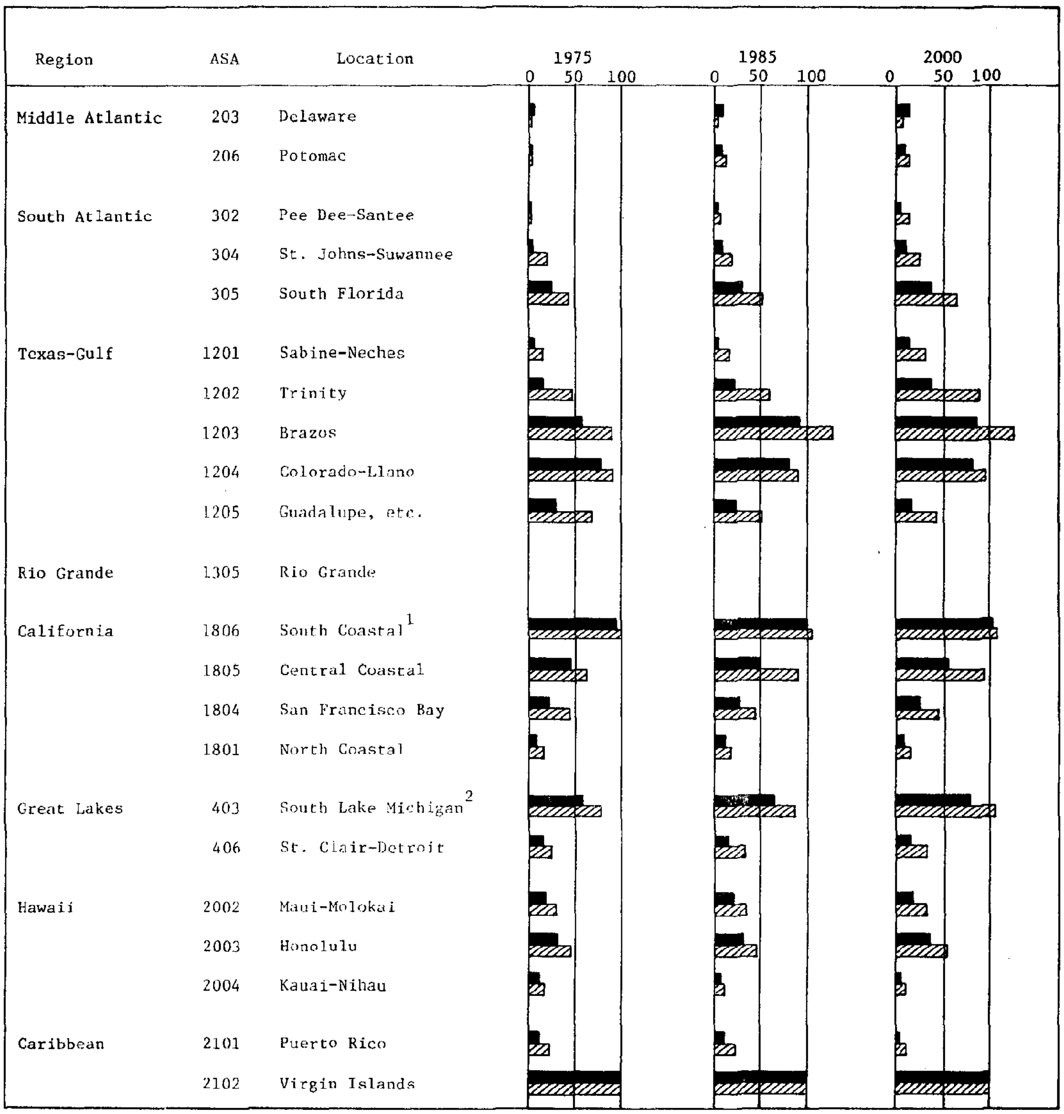
Figure 4.1 indicates the projected consumptive demand for fresh water as a percent of the projected supply for selected ASA's along the coastal United States. Only those ASA's in which the demand is greater than five percent of the supply are shown. Supply flows are probabilistic in nature and are expressed as flow at a given percent annual probability. For example, freshwater supply at the 50 percent exceedance level is that amount of fresh water which can be assured to users during 50 out of 100 years; in the remaining years, lesser amounts are available. The figure graphically detects those areas where problems in water supply and demand are critical and the changes expected over the next 25 years. These include Southern Florida, the Texas-Gulf coast, the Central and Southern California coast. The Southern Lake Michigan ASA is a special case where use will exceed land drainage, but the Lake itself is a vast supply of fresh water. The Virgin Islands have not had an adequate natural supply of fresh water for some time, and the demand on St. Thomas and St. Johns is met by barging water from Puerto Rico and desalination in St. Thomas. The bays of the Virgin Islands are not true estuaries as the surface runoff is very intermittent, occurring mostly during August, September, and October in periods of tropical storms. A number of embayments of the Hawaiian Islands also do not qualify as estuaries as they do not have sufficient freshwater input but can be significantly affected by man's activities.

PATTERNS OF WATER USE

Water supplies to the estuaries are generally affected by increasing consumption rather than a change in the water sources themselves, although the temporal flow of water may be altered through the use of flow control dams and a few river basin diversions. In order to identify the significant changes in water use, Tables 4.1 and 4.2 were constructed. These tables indicate the percent changes in consumptive water use by categories using 1975 use as a base. Since a large percentage change does not necessarily indicate a large consumptive use, another factor, the percentage that category is of the total consumptive use for the ASA, is also shown. Those uses which represent greater than 25 percent of the total consumptive use and those representing greater than 25 percent increase in demand over 1975 levels are highlighted.

It is evident immediately that manufacturing will require the greatest increase in consumptive water use by 1985. These demands will be concentrated in the Middle Atlantic (Delaware and Potomac), the Great Lakes, and the Texas-Gulf coast. Water for condenser cooling purposes in steam electric generation will be in demand in North Carolina by 1985. Other increasing demands will be for domestic water supplies in Hawaii and crop irrigation in Florida, Texas, and Lower California. By the year 2000,

Figure 4.1. Water Demand as a Percent of Supply



Key: Percentage based on 50% exceedance flow

Percentage based on 95% exceedance flow

[1]Data do not distinguish between coastal area and Colorado Desert drainage. Includes import of 4651.5 MGD (3/4 of supply).

[2]Demand includes export of 982.1 MGD.

Table 4.1. Consumptive Water Use by Categories for 1985. Percent Change from 1975 and Percent of Total Requirement.

Area	Aggregated Subarea	Location	Year 1985 Consumptive Use: Domestic	Manu-facturing	Minerals	Crop Irrigation	Live-Stock	Steam Electric	National Forests	Total
Middle Atlantic	203	Delaware	10/12	30/49		36/18		192/9		16
	206	Potomac	26/17	253/48	40/7	50/6		-33/3	41/1	80
South Atlantic	302	Pee Dee-Santee-Edisto	19/12	2/34	28/1	29/5	21/<1	309/32		45
	304	St. Johns to Suwannee	24/10	204/10	23/<1	19/75	10/1	117/2		28
	305	Southern Florida	32/6	127/4	32/3	11/85		356/2		16
Great Lakes	402	Northwestern Lake Michigan		243/39		55/22		94/16	44/<1	84
	403	Southern Lake Michigan	9/18	30/58		56/1		178/15		14
Texas-Gulf	1201	Sabine-Neches	16/4	78/35	-7/9	-17/39	10/3	550/6		15
	1202	Trinity	20/8	132/35	16/6	-19/43	5/2	47/2		15
	1203	Brazos		34/<1	4/<1	20/95		421/1		21
	1204	Colorado-Llano	10/1	57/<1	7/9	-14/84	6/<1	266/1		-10
	1205	Guadalupe-San Antonio-Nueces-Frio	9/6	-64/10		-8/62	7/4	35/1		-20
California-South Pacific	1804	San Francisco Bay	14/23	118/10		1/64				-0.2
	1805	Central Coastal	12/4	20/2		5/91				6
	1806	South Coastal-Colorado Desert	12/11	36/1		6/82	20/<1	250/<1		8
Hawaii	2002	Maui-Molokai-Lanai-Kahoolawe	28/2			-5/89				3
	2003	Oahu-Honolulu	13/25	142/11		-6/62				5
Caribbean	2101	Puerto Rico			23/1	-4/96	4/2			-3

% increase in consumptive use over 1975 use.
% this use is of total consumptive use.

increased demand where use is >¼ total requirement.

increased demand where use is >¼ total requirement and increase >¼.

decreased demand since 1975.

Table 4.2. Consumptive Water Use by Categories for 2000. Percent Change from 1975 and Percent of Total Requirement.

Area	Aggregated Subarea	Location	Year 2000 Consumptive Use: Domestic	Manu-facturing	Minerals	Crop Irrigation	Live-Stock	Steam Electric	National Forests	Total
Middle Atlantic	203	Delaware	26/9	63/46		77/18		662/17		38
	206	Potomac	66/8	980/60	108/4	111/4		755/14	94/<1	343
South Atlantic	302	Pee Dee-Santee-Edisto	46/7	145/40	76/1	61/3	47/<1	958/40	94/<1	1995
	304	St. Johns to Suwannee	60/10	571/17	69/<1	33/67	30/1	208/2		59
	305	Southern Florida	83/7	477/8	84/3	22/78		1056/3		39
Great Lakes	402	Northwestern Lake Michigan		883/53		116/15		400/20	92/<1	285
403	403	Southern Lake Michigan	23/18	80/55		119/1		554/25		39
Texas-Gulf	1201	Sabine-Neches	36/2	262/41	-13/4	-31/19	31/2	4833/28	86/<1	98
	1202	Trinity	49/6	489/56	35/5	-33/23	24/1	361/5		80
	1203	Brazos		86/<1	10/<1	-9/93		794/2		-6
	1204	Colorado-Llano	23/1	264/<1	16/11	-31/72	25/<1	1725/9		-17
	1205	Guadalupe-San Antonio-Nueces-Frio	20/7	-45/19		-35/54	27/5	14/1		-30
California-South Pacific	1804	San Francisco Bay	36/25	306/17		-1/56				-1
	1805	Central Coastal	31/4	70/3		5/88				11
	1806	South Coastal-Colorado Desert	29/13	104/2		4/29	42/<1	543/1		10
Hawaii	2002	Maui-Molokai-Lanai-Kahoolawe	71/2			-13/73				16
	2003	Oahu-Honolulu	31/26	442/21		-12/51				20
Caribbean	2101	Puerto Rico			53/2	-45/93	83/4			-42

% increase in consumptive use over 1975 use.
% this use is of total consumptive use.

increased demand where use is >¼ total requirement.

increased demand where use is >¼ total requirement and increase >½.

decreased demand since 1975.

manufacturing and the electric generating industry will have the greatest increase in water demands. The demand for manufacturing will be felt in the Delaware-Potomac areas, North Carolina, Lake Michigan, and the Texas-Gulf coastal area. Increasing demands for cooling water will be found in North Carolina, Lake Michigan, and the Texas coast. Demands for irrigation water will continue to be felt in Florida and central and southern California. Increased demands for domestic water supplies will be in the San Francisco Bay area and Honolulu, and the demands of the Virgin Islands will continue to be met by desalination and barging water from Puerto Rico.

SEASONAL AND ANNUAL FRESHWATER OUTFLOWS

The demand/supply data thus far presented are based on annual average flows which do not necessarily reflect the extreme low flow conditions. Water discharges into the estuaries fluctuate widely under natural conditions, both seasonally and annually as can be seen in Tables 4.3 and 4.4. Low flows are generally found in the summer and fall months except in Florida where the lowest flows are during winter and spring. In the Potomac River, for example, there is a 50 percent chance that the average flow in September will be less than 2,516 MGD which is less than 30 percent of the annual mean discharge. Furthermore, there is a 5 percent chance that the discharge in August will be less than 1,161 MGD or 13 percent of the average annual discharge from the Potomac.

In the Southern Florida ASA, even more extreme seasonal fluctuation is evident. Here, there is a 50 percent chance that the discharge in April will be less than 103 MGD which is only 14 percent of the mean annual discharge rate of 7,420 MGD. Likewise, there is a 5 percent chance that the discharge will be less than 4 MGD or 0.05 percent of the mean annual discharge rate. In addition, the annual average discharge in Southern Florida is also highly variable. There is a 20 percent chance that the annual average discharge will be less than 4,130 MGD which is 56 percent of the mean annual discharge. In addition, there is a 5 percent chance that the annual average flow will be only 35 percent of the mean annual discharge.

Along the Texas-Gulf coast, in the Galveston Bay area for example, there is a 50 percent chance that the average flow for August will be less than 1,032 MGD or 14 percent of the mean annual discharge of 7,470 MGD. Likewise, there is a 5 percent chance that the October average discharge into the estuary will be less than 161 MGD or 2 percent of the mean annual discharge. The mean annual discharge also fluctuates widely. For example, there is a 20 percent chance that the annual average discharge will be only 42 percent of the mean annual discharge and a 5 percent chance that it will only be 19 percent of the mean annual discharge. This undoubtedly is a result of the effects that occasional hurricanes have on the mean annual discharge values, but nevertheless the data show the large fluctuations that occur naturally in this estuarine area, and yet the estuary is still highly productive and supports a variety of fish and wildlife resources.

Table 4.3 Outflows from ASA's in MGD - Monthly flow at 50% chance of being exceeded as a mean.

	Potomac	Southern Florida	Sabine-Neches	Trinity Galveston Bay	Brazos	Colorado Llano	Guadalupe-Nueces	South Coastal	Central Coastal	San Francisco Bay	Southern Lake Michigan	Oahu
ASA	206	305	1201	1202	1203	1204	1205	1806	1805	1804	403	2003
Annual	8,708	6,579	8,256	6,192	3,354	1,354	3,418	342	1,032	3,160	1,161	367
Oct.	2,967	9,223	1,935	1,419	1,484	968	1,935	31	110	380	452	187
Nov.	3,999	3,547	2,128	2,322	1,677	838	1,354	181	219	710	593	348
Dec.	5,418	903	5,934	3,418	1,806	838	1,483	284	452	2,580	600	419
Jan.	7,740	709	9,159	4,580	1,935	838	1,612	710	1,419	6,321	632	484
Feb.	11,674	464	9,868	6,063	2,902	1,161	1,612	1,096	1,935	7,417	968	387
Mar.	18,189	361	10,836	5,676	1,677	774	1,548	574	1,226	4,966	2,193	355
Apr.	13,480	103	10,191	6,128	2,064	744	1,742	368	903	2,902	2,064	413
May	9,998	187	11,158	7,740	4,128	1,354	2,774	71	355	838	1,096	284
June	6,450	1,612	7,611	4,902	3,225	1,032	2,386	31	181	342	645	116
July	3,354	7,675	4,128	2,000	1,032	838	2,838	23	110	194	471	194
Aug.	3,160	8,514	2,258	1,032	393	478	1,484	19	77	174	368	168
Sept.	2,516	8,191	2,516	1,161	1,161	903	1,935	26	77	194	393	116

Low flows.

Table 4.4. Outflows from ASA's in MCD - Monthly flow at 95% chance of being exceeded as a mean.

	Potomac	Southern Florida	Sabine-Neches	Trinity-Galveston Bay	Brazos	Colorado-Llano	Guadalupe Nueces	South Coastal	Central Coastal	San Francisco Bay	Southern Lake Michigan	Oahu
ASA	206	305	1201	1202	1203	1204	1205	1806	1805	1804	403	2003
Annual	4,322	2,580	3,031	1,419	774	322	645	52	161	1,096	484	181
Oct.	1,290	3,741	426	161	116	187	368	5	35	103	110	43
Nov.	1,677	709	522	264	264	142	445	6	52	148	161	71
Dec.	1,935	129	1,226	458	252	155	490	10	71	226	142	103
Jan.	2,838	90	2,451	613	206	155	535	37	155	903	155	155
Feb.	5,354	64	2,516	1,354	426	187	710	20	290	1,419	213	103
Mar.	9,224	20	3,096	1,096	232	116	522	11	187	1,226	774	84
Apr.	6,321	4	2,322	1,161	271	90	458	11	116	529	710	110
May	4,773	6	2,128	1,354	355	155	303	6	84	245	271	77
June	2,451	77	1,677	710	439	110	774	4	58	142	212	32
July	1,484	1,419	1,290	335	103	24	348	3	37	97	129	50
Aug.	1,161	2.386	710	213	77	110	471	3	30	103	97	46
Sept.	1,226	2,709	632	194	155	168	361	4	31	122	90	48

Low flows.

The southern coast of California is an example of an area which has a natural paucity of freshwater discharge to the few major estuaries that exist there. During the summer months, there is a 50 percent chance that the average discharge will be less than 19 MGD, which is little more than 4 percent of the mean annual discharge of 445 MGD. There is a 5 percent chance that the flows will be less than 3 MGD, less than 0.6 percent of the mean annual discharge rate. Stream flows into these estuaries are intermittent and substantial freshwater input is normally limited to the winter months. Newport Bay, for example, is a relic estuary, originally formed by large discharges but now receiving drainage from a semi-arid region. It therefore is characteristically marine most of the year. Central Coastal California and San Francisco Bay tributaries have highly variable seasonal and annual flows.

Southern Lake Michigan tributaries are not as highly variable from month to month but have a typical peak discharge during the spring thaw.

EFFECTS OF INCREASED CONSUMPTIVE USE

Reduction of freshwater flows into an estuary can affect the estuary in a number of ways: 1) increased salinity, 2) increased flushing time, 3) change in circulation, and 4) decreased sedimentation.

All definitions of an estuary include mixing of sea water with fresh water, but the amount of fresh water in proportion to the size of the estuary varies enormously, not only from one estuary to another, but also seasonally within a single estuary. The biota found with an estuary reflect the relative stability or instability of the salinity regime existing there, and any change in the freshwater input will likewise affect the salinity regime and the biotic communities. Within the lower reaches of a river or in a bay or sound, salinity is a continuum, diminishing upstream and increasing toward the sea. The continuum is dynamic, however, in that it fluctuates in response to tidal influence, weather conditions, and freshwater discharge. A decrease in discharge in general moves the isohalines further upstream. Significantly, the lowest diversity of organisms is found in the transition zone between salt and fresh water where salinity fluctuates most widely.

Probably the most significant effect caused by reduction of freshwater flows is the change of salinity and its resulting effect on fish and wildlife habitats. In tidal rivers such as the Potomac, a reduction of freshwater flow has the same effect as low flow conditions in the summer months; it moves the isohalines upstream but on a permanent basis. Infauna requiring a particular range of salinities reestablish themselves further upstream. Existing oyster beds are subjected to higher salinities and those in the lower reaches may be subjected to predators such as the oyster drill and the probability of infectious oyster diseases such as MSX which are salinity-limited under normal conditions. New oyster rocks and cultch would have to be established further upstream in order for the larval oyster set to remain viable. Normal spawning and nursery areas for anadramous fish such as herring and shad might be reduced in size. This might be significant if suitable bottoms were not available or if a physical barrier to upstream migration were present. In cases such as the Potomac, the size and salinity of the receiving body of water (the Chesapeake Bay) determine the extent of salinity change in the river caused by a reduction in freshwater flow. Along the Texas-Gulf coast and south coastal California are examples of estuaries deprived of substantial freshwater inflow and consequently are of high salinity, as discussed later.

The damming of rivers and reductions in flow reduce the amount of sediment reaching the estuaries. The sediments themselves are important in controlling the ecosystem as they are sites for the sorption of nutrients and for microbial activity responsible for the decomposition of organic matter. In some cases, this can be an advantage, particularly where navigation channels must be maintained. In other cases where large flows are prevalent, deltas depend upon this continued nourishment by sediments. Without the sediment load and coastwise dispersion, erosion takes place with the loss of beaches and the deltas themselves. In the latter case, a change of wildlife habitat results.

SUMMARY

The impacts of projected water use and supply for the years 1985 and 2000 on estuarine and nearshore environments and resources when viewed on a regional basis are insignificant.

When individual ASA's are examined, however, certain regions appear to face possible significant impacts. The ASA's in which estuaries might receive the highest impacts because of changes (principally increases in water use) lie along the Texas-Gulf coast. Water use in certain ASA's (Trinity, 1202; Brazos, 1203; Colorado-Llano, 1204) is projected to increase to such an extent that extensive salinity alteration may occur.

Along the Texas-Gulf coast, the Laguna Madre and Baffin Bay are examples of shallow estuaries where evaporation in this arid climate has exceeded freshwater inflow resulting in hypersaline conditions. Further east, the Nueces River feeds Corpus Christi Bay and the Guadalupe and San Antonio rivers empty into San Antonio Bay. Connections with the Gulf of Mexico are quite restricted, therefore reduction of flow would undoubtedly increase the salinity of the extensive bay system. The Colorado and Brazos rivers empty directly to the Gulf of Mexico, but the Trinity and San Jacinto rivers feed the extensive Galveston Bay complex. Again, passes through the barrier islands are limited and reduction of flow would increase the salinity from the present average of about 12 ppt. A significant increase could seriously affect the shrimp and shellfish industries, and valuable nursery areas could be lost.

Although the assumption has been made that the 1983 Water Quality Goals will be met by 1985, it should be noted that the flushing of estuaries is partly a function of freshwater flow, and a reduction of flow would tend to increase the concentration of pollutants within the estuaries unless they can be reduced at the source. Since the Texas bays have a tidal range of only about 0.5 feet, the flushing characteristics must be considered along with freshwater input.

Though not an estuarine or nearshore environment of the coastal United States, the Gulf of California is a region that might also face similar problems. Water use projections for the Lower Colorado Region (ASA 1502) and the Rio Grande Region (ASA 1305) are similar to those in some of the Texas-Gulf ASA's. If U. S. water demands in this region did impact the receiving body or water supply, possible international ramifications might arise.

Although, with the few exceptions mentioned, projected water use demands for 1985 and 2000 do not appear to offer a major threat on a regional or ASA basis, a word of caution must be interjected. Back extrapolation from the general case to the specific case may not provide accurate predictions of impacts of water use demands. It is possible to envision two small watersheds within a given ASA, both of which have estuarine areas in the lower reaches, in which water demands of one far exceed supply, while certain factors (such as, for example, discharges from other watersheds) can cause supply to greatly increase and exactly balance the excess use on our first watershed. Analysis by ASA in this instance would indicate no use changes yet the impact on the two estuaries in question could be marked.

While it is reasonable to state that from a national perspective no major concern with regard to impacts of projected water use on estuarine and nearshore environments be expressed, the case of individual systems is different.

Detailed area related analysis must be made on each estuarine area threatened with water supply modifications before accurate assessments of the impacts of these changes can be made.

Although estuarine systems are adapted to widely fluctuating natural flow conditions, long term alterations of an area's water supply (be it increased or decreased) may have marked effects both on the resources present and on the ability of the system to rebound to its normal condition.

Appendix 1. Partial List of Estuarine Dependent and Nearshore Marine Species.

FISH:	
alewive	Alosa pseudoharengus
anchovies	Engraulis mordax (Pacific)
	Anchoa sp. (Atlantic)
bluefish	Pomatomus saltatrix
burbot	Lota lota
bass	Morone sp.
bass, black sea	Centropristis striata
bass, largemouth	Micropterus salmoides
bass, striped	Morone saxatilis
carp	Cyprinus carpio
catfishes	Ictaluridae
char, Arctic	Salvelinus alpinus
cisco (lake herring)	Coregonus (Leucichthys) artedii
cod	Gadus sp.
crevalle	Caranx hippos
croaker, Atlantic	Micropogon undulatus
Dolly Varden	Salvelinus malma
drum, black	Pogonias cromis
drum, red	Sciaenops ocellata
eel, common	Anguilla rostrata
flounders	Bothidae; Pleuronectidae
goatfish	Mullidae
herring, blueback	Alosa aestivalis
herring, Pacific	Clupea harengus pallasi
hogchoker	Trinectes maculatus
kingfish	Menticirrhus sp.
menhaden	Brevoortia sp.
minnows	Cyrpinidae
mullet	Mugil sp.
perch, white	Morone americana
perch, yellow	Perca flavescens
pigfish	Orthopristis chrysopterus
pike, blue*	Stizostedion vitreum glaucum
pike, northern	Esox lucius
pinfish	Lagodon rhomboides
pompano	Trachinotus sp.
porgies	Calamus sp.
rockfish	Sebastodes sp. (Pacific)
sablefish	Anoplopoma fimbria
salmon, Atlantic	Salmo salar
salmon, chinook (king)	Oncorhynchus tshawytscha
salmon, chum	Oncorhynchus keta
salmon, coho (silver)	Oncorhynchus kisutch
salmon, pink	Oncorhynchus gorbuscha
salmon, sockeye (kokanee, red)	Oncorhynchus nerka
scad, bigeye	Selar crumenophthalmus
scad, mackerel	Decapterus macarellus
shad, American	Alosa sapidissima
silversides	Medidia spp.
smelt	Atherinidae; Osmeridae
snappers	Lutjanidae
snook	Centropomus undecimalis
spot	Leiostomus xanthurus
sturgeon	Acipenser sp.
	Scaphirhynchus sp.
FISH (Cont'd):	
sunfish	Lepomis sp.
tarpon	Megalops atlantica
tautog	Tautoga onitis
threadfin, Pacific	Polydactylus approximans
trout, brook	Salvelinus fontinalis
trout, brown	Salmo trutta
trout, cutthroat	Salmo clarki*
trout, lake	Salvelinus namaycush
trout, rainbow (steelhead)	Salmo gairdneri
trout, spotted sea	Cynoscion nebulosus
walleye	Stizostedion vitreum vitreum
whitefish, lake	Coregonus clupeaformis
CRUSTACEANS:	
crab, blue	Callinectes sapidus
crab, dungeness	Cancer magister
crab, green	Carcinus maenas
crab, king (Alaska king crab)	Paralithodes camschatica
crab, rock	Cancer irroratus (Atlantic)
	Cancer sp. (Pacific
crab, stone	Menippe mercenaria
crab, tanner	Chionoecetes sp.
crawfish, fresh-water	Cambarus sp. (Atlantic)
	Astacus sp. (Pacific)
lobster, northern	Homarus americanus (Atlantic)
lobster, slipper	Scyllarides sp.
lobster, spiny	Panulirus argus (Atlantic)
	Panulirus interruptus (Pacific)
shrimp	Penaeus sp.; Pandalus sp.; Xiphopenaeus sp.; Pandalopsis sp.; Crangon sp.
MOLLUSKS:	
abalone	Haliotis sp.
clam, butter	Saxidomus nuttalli (Pacific)
clam, little neck	Protothaca staminea (Pacific)
clam, manila	Corbicula manilensis
clam, pismo	Tivela stultorum
clam, razor	Ensis sp. (Atlantic)
	Siliqua patula (Pacific)
clam, soft	Mya arenaria
clam, surf	Spisula solidissima
clam, venus	Mercenaria mercenaria
cockles	Littorina sp.
conchs	Strombus sp.; Busycon sp.
coquina	Donax sp.
geoducks	Panope generosa
limpets	Crepidula sp.
mussel	Mytilus sp.
octopus	Paroctopus appollyon
oyster, eastern	Crassostrea virginica
oyster, Pacific	Crassostrea gigas
oyster, western	Ostrea lurida
Rangia	Rangia sp.
scallops, bay	Pecten sp.
scallops, sea	Placopecten magellanicus

*On endangered species list.

Appendix 2. List of Species Under Each Waterfowl Harvest Category

Diving Ducks	Dabbling Ducks	Geese
Redhead	Mallard	Snow Goose
Canvasback	Mallard H.R.	White Morph
Greater Scaup	Mallard X.B.	Dark Morph
Lesser Scaup	Black Duck	Ross' Goose
Ringneck	Mexican Duck*	White-fronted Goose
Common Goldeneye	Mottled Duck	Canada Goose
Barrows Goldeneye	Gadwall	Brant
Bufflehead	American Wigeon	Black Brant
Ruddy Duck	Green-winged Teal	Emperor Goose
Masked Duck	Blue-winged Teal	
Oldsquaw	Cinnamon Teal*	
Harlequin	Muscovy*	
Common Eider	Northern Shoveler	
King Eider	Pintail	
Black Scoter	Wood Duck	
White-winged Scoter	Black-bellied Tree Duck	
Surf Scoter	Fulvous Tree Duck	
Hooded Merganser	Miscellaneous hybrids	
Red-breasted Merganser		
Common Merganser		

Source: U. S. Department of Interior, Fish and Wildlife Service, Unpublished data from Chief, Waterfowl Harvest Surveys, Office of Migratory Bird Management, Laurel, Maryland.

*Rare or endangered.

Appendix 3. Projected Changes in Population for Water Resource Regions[1].

Region	Population 1975 (1,000)	Population 1985 (1,000)	Change 1975-1985 (%)	Population 2000 (1,000)	Change 1985-2000 (%)
New England	12,492	13,613	8.96	15,313	12.49
Middle Atlantic	39,612	43,873	10.76	49,939	13.83
South Atlantic	14,858	17,311	16.51	20,750	19.87
East Gulf	10,565	12,024	13.81	13,930	15.84
Lower Mississippi	6,418	6,767	5.43	7,142	5.55
Texas-Gulf	9,911	11,163	12.63	12,906	15.62
California-South Pacific	21,159	23,703	12.02	27,093	14.30
Columbia-North Pacific	6,703	6,991	4.30	7,589	8.56
Alaska	307	361	17.70	438	21.33
Great Lakes	30,390	32,855	8.11	36,351	10.64
Hawaii	787	911	15.72	1,085	19.16
Total or Average (Regions)	153,200	169,572	10.69	192,536	13.54
Total or Average (U.S.)	213,325	234,517	9.93	263,830	12.50

Source: Calculated from "Series E" Projections and Historical Data, Population, Personal Income and Earnings, Aggregated Subareas, June, 1974, U.S. Water Resources Council.

[1]Excludes Caribbean Area.

Appendix 4. Projected Per Capita Income for Water Resource Regions[1].

Region	Per Capita Income 1975 (1967 $)	Relative (U.S.=1.00)	1985 (1967 $)	Relative (U.S.=1.00)	2000 (1967 $)	Relative (U.S.=1.00)
New England	4,350	1.07	5,822	1.07	8,701	1.07
Middle Atlantic	4,653	1.14	6,131	1.13	9,044	1.11
South Atlantic	3,437	.84	4,650	.86	7,151	.88
East Gulf	3,437	.84	4,650	.86	7,151	.88
Lower Mississippi	3,119	.77	4,240	.78	6,645	.81
Texas-Gulf	3,785	.93	5,073	.93	7,693	.94
California-South Pacific	4,557	1.12	5,965	1.10	8,822	1.08
Columbia-North Pacific	3,872	.95	5,290	.97	8,005	.98
Alaska	4,932	1.21	6,340	1.17	9,333	1.14
Great Lakes	4,418	1.09	5,903	1.09	8,803	1.08
Hawaii	4,702	1.16	6,041	1.11	8,823	1.08
U.S. Average	4,070	1.00	5,429	1.00	8,165	1.00

Source: "Series E" Projections and Historical Data, Population, Personal Income and Earnings Aggregated Subareas, June, 1974, U.S. Water Resources Council.
[1]Excludes Caribbean Area.

Appendix 5. Present Status of Selected Species (Including Estuarine and Near Shore Marine Dependent) of Interest to U.S. Fishermen.

Potential for Increased Catch	Fully Utilized	Overfished
Pacific rock sole	Atlantic mackerel[1,2]	Yellowfin sole
Alaska herring	Red hake[1]	Alaska pollock
N. E. Pacific shrimp	Silver hake	Pacific ocean perch
Sea trouts[2]	Atlantic herring	Pacific halibut
King mackerels[2]	Atlantic squid	Atlantic halibut
Mullets	Bering Sea cod	Bering Sea herring
California anchovy	King crab	Bering Sea shrimp
Blue crab	Tanner crab	Haddock[1]
Rock crab	Pacific hake	Yellowtail flounder[1]
Jonah crab	Atlantic cod[1,2]	California sardine
Surf clam	Atlantic ocean perch	Pacific mackerel
Ocean quahog	Bluefish	Atlantic sea scallop
Gulf of Mexico clupeids	Menhadens	N. W. Atlantic shrimp
Oysters	American lobster	Atlantic bluefish tuna
Hard clam	Gulf shrimps	
Calico scallop	Eastern Trop. Pacific Yellowfin tuna[1]	
Pacific salmon		
Skipjack		

Source: National Fisheries Plan - Review Paper on Issues and Options, National Marine Fisheries Service, NOAA, (April 1975).
[1]Under international regulation.
[2]Significant recreational fishery.

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